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FEASIBILITY STUDY

REPORT

ROLLING KNOLLS LANDFILL SUPERFUND SITE

CHATHAM, NEW JERSEY

Prepared for

Rolling Knolls Landfill Settling Parties

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ACRONYMS

ALM	Adult Lead Methodology
APC	Area of Potential Concern
ARAR	Applicable or Relevant and Appropriate Requirement
ARS	Alternative Remediation Standard
BERA	Baseline Ecological Risk Assessment
BGS	Below Ground Surface
BHHRA	Baseline Human Health Risk Assessment
BMPs	Best Management Practices
BTV	Background Threshold Value
CCP	Comprehensive Conservation Plan
CEA	Classification Exception Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Constituent of Concern
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CTBH	Chatham Township Board of Health
CTE	Central Tendency Exposure
cyd	Cubic Yard
DSRA	Development and Screening of Remedial Alternatives
ELCR	Excess Lifetime Cancer Risk
ERAGS	Ecological Risk Assessment Guidance for Superfund
FHA	Flood Hazard Area
FS	Feasibility Study
GSNWR	Great Swamp National Wildlife Refuge
GVFD	Green Village Fire Department

GWQS	Ground Water Quality Standard
HASP	Health and Safety Plan
HI	Hazard Index/Indices
HQ	Hazard Quotient
HQ _{LOAEL}	Hazard Quotient for the lowest observable adverse effect limit
HQ _{NOAEL}	Hazard Quotient for No Observed Adverse Effect Level
HQ _{sed}	Hazard Quotient for sediment
IGWSSL	Impact to Ground Water Soil Screening Level
MESA	Memorandum on Exposure Scenarios and Assumptions
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Liter
MNA	Monitored Natural Attenuation
NCP	National Contingency Plan
ND	Not Detected
N.J.A.C.	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NRDCSRS	Non-Residential Direct Contact Soil Remediation Standard
O&M	Operation and Maintenance
OSHA	Occupational Safety and Health Administration
PAH	Polycyclic Aromatic Hydrocarbon
PAR	Pathways Analysis Report
PbB	Blood Lead Concentration
PCB	Polychlorinated Biphenyls
PCDD/F-TEQ	Polychlorinated Dibenzo-p-Dioxin/Furan Toxic Equivalent Quantity
POI	Point of Interest
PRG	Preliminary Remediation Goal
RA	Remedial Action

RAO	Remedial Action Objective
RDCSRS	Residential Direct Contact Soil Remediation Standard
rERA	Residual Ecological Risk Assessment
RI	Remedial Investigation
RIR	Remedial Investigation Report
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SCSR	Site Characterization Summary Report
SEM-AVS	Simultaneously Extracted Metals/Acid Volatile Sulfide
SI	Site Investigation
SLERA	Screening Level Ecological Risk Assessment
SRS	Soil Remediation Standards
SVOC	Semi-Volatile Organic Compounds
SWQS	Surface Water Quality Standards
TAL	Target Analyte List
TBC	To Be Considered
TCL	Target Compound List
TMCT	Technical Memorandum on Candidate Technologies
TOC	Total Organic Carbon
TRV	Toxicity Reference Values
µg/dL	Micrograms per Deciliter
USEPA	United States Environmental Protection Agency
USFWS	United States Fish & Wildlife Service
UST	Underground Storage Tank
VI	Vapor Intrusion
VOC	Volatile Organic Compound
WRA	Well Restriction Area

EXECUTIVE SUMMARY

This Feasibility Study Report (FS Report) has been prepared for the Rolling Knolls Landfill Superfund Site (the Site) in Chatham, New Jersey (listed on the National Priorities List in September 2003). The purpose of this FS Report is to develop and screen potential remedial alternatives and to conduct a detailed evaluation of each remedial alternative identified for soil and groundwater to reduce unacceptable risks to human health and the environment. The results of this FS will be used by United States Environmental Protection Agency (USEPA) to develop a Proposed Plan for remedial action and a Record of Decision for the Site.

The area of the Site where waste disposal occurred covers approximately 170 acres, consisting of 140 acres of landfill with a layer of waste material (18 feet or less in thickness) overlying native soil and an approximately 30-acre area adjacent to the landfill with isolated areas of debris scattered on the ground surface, but with no buried waste, referred to as the Surface Debris Area. The landfill was used for disposal of municipal waste from Chatham Township and nearby municipalities from the 1930s to approximately 1968. Landfilled materials are generally consistent with typical municipal solid waste expected within a landfill that operated during this period. Evidence of potential industrial waste, identified based on visual observations and analytical results, was observed at three isolated areas, comprising only a small proportion of the total volume of waste disposed of at the landfill. The landfill is covered in some areas by a thin layer of soil and/or vegetation, and in others the waste is visible at the surface. Historical operations of the landfill included the application of pesticides for mosquito and rodent control on the landfill and the surrounding area.

Of the 170 acres that comprise the landfill and the Surface Debris Area, approximately 100 acres of the landfill and the 30-acre Surface Debris Area are on land owned by the Trust created by the Last Will and Testament of Angelo J. Miele (Miele Trust). Approximately 35 acres of the landfill are on land that is part of the Great Swamp National Wildlife Refuge (GSNWR) which is owned by the United States and operated by the United States Fish and Wildlife Service (USFWS). Approximately 5 acres of the northeastern portion of the landfill are on land owned by the Green Village Fire Department (GVFD). The GVFD property also includes a Baseball Field and Shooting Range. Based on the results of the Remedial Investigation (RI) activities, the Baseball Field and Shooting Range were found to be outside the landfill boundary and are not impacted by the waste materials. A small portion of the Surface Debris Area, approximately 4,000 square feet, extends on to an adjacent property currently owned by David M. Bakunas, Trustee.

The Site is located at the southern end of Britten Road in the Green Village portion of Chatham Township. Green Village is a scenic, rural village oriented along Green Village Road. Green Village Road is a 2-lane (one in each direction) county road with residential and limited commercial development on each side. Britten Road intersects Green Village Road and is primarily residential. Britten Road is approximately 1.5 lanes wide and is the only road that provides access to the Site. The Site is approximately 5.5 miles from the nearest major road, State Route 24, and is accessible only by driving through residential and commercial areas of Chatham.

Wetlands and flood hazard areas (FHAs) occupy the adjacent areas to the east, south, and west of the Site and portions of the landfill itself. Areas on and adjacent to the landfill provide habitat for native mammals, fish, amphibians, and reptiles, including the endangered bog turtle, Indiana bat, and blue-spotted salamander.

Site conditions and constituent concentrations in soil, sediment, surface water, and groundwater have been characterized through several phases of investigation since 2007. Analytical results indicate that volatile organic compounds (VOCs), metals, semi-volatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyls (PCBs) are present in surface soil at concentrations greater than the New Jersey Non-Residential Direct Contact Soil Remediation Standards (NRDCSRS) and/or the New Jersey Residential Direct Contact Soil Remediation Standards (RDCSRS). Certain VOCs, SVOCs, PCBs, and pesticides are present in groundwater in limited areas of the Site and certain, and metals are also present at concentrations above their respective New Jersey Ground Water Quality Standards (GWQS), in groundwater. Except for the metals, these groundwater impacts are only in limited areas of the Site. The metals, which are common in groundwater within this region of New Jersey, were found in groundwater below and near the landfill.

Ecological and human health risk assessments have been completed to assess the risks associated with the Site. The primary human health risk constituents of concern (COCs) for the current and reasonably anticipated future exposures are non-dioxin-like PCBs. The human health risk assessment indicated that, for current exposures and reasonably anticipated future exposures, all estimated cancer risks and the majority of non-cancer health hazard to human receptors are within or less than USEPA target levels. For landscapers that currently store and maintain equipment in one area of the landfill, the estimated non-cancer hazard is slightly greater than the USEPA target level, but Hazard Indices for individual target organs are all less than or equal to the USEPA target level of 1. Under the reasonably anticipated trespasser exposure scenario, discussed below, the

estimated non-cancer health hazard to adolescent and adult trespassers that at times may enter the landfill, or that may reasonably be anticipated to enter the landfill in the future, is greater than the USEPA target level.

The results of the ecological risk assessment indicate that exposures to constituents in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors, and that there is a low potential risk for vermivorous birds (e.g., American robins) and mammals (e.g., short-tailed shrew) through exposure to PCBs and certain metals in soil.

Remedial options were evaluated and designed to address the exposure risks that are reasonably anticipated to occur. Based upon an agreement the Group is working to finalize with the Miele Trust, the portion of the Site located on the Miele Trust property will be preserved as open space in perpetuity. Similarly, the area of the Site in the Great Swamp is also preserved with no future development. The small portion of landfill on the GVFD property is not eligible for development. Accordingly, while the Baseline Human Health Risk Assessment (BHHRA) evaluated risks to potential receptors if the Site were to be developed residentially, such use is not reasonably anticipated to occur. Further, there will be no commercial, industrial, recreational, or any other use. The only reasonably anticipated human exposures are to trespassers.

Statistical analysis using the concentrations of the primary human health risk driver in soil (non-dioxin-like PCBs) identified an approximately 25-acre area of the Site (referred to as the Selected Area) which if remediated would lower the overall human health risk levels at the Site to below USEPA's acceptable risk range. Remediation of this area will also reduce the residual risks to vermivorous birds and mammals, based on a statistical analysis conducted using information from the Baseline Ecological Risk Assessment (BERA) from PCBs and the metals that pose potential ecological concern (barium, cadmium, chromium, copper, cyanide, lead, methylmercury, nickel, selenium, and zinc), based on the results of a residual ecological risk assessment.

In addition to the Selected Area, additional areas were considered for remediation based on several different criteria. First, since the reasonably anticipated future Site use only results in potential human exposure to trespassers, Alternative Remediation Standards (ARSs) were developed in accordance with NJDEP regulations (N.J.A.C. 7:26D; NJDEP, 2017) to account for the exposure scenarios that are appropriate to that use. Thus, ARSs were developed for constituents that exceeded New Jersey's NRDCSRS. Based on the ARSs, seven Areas of Particular Concern (APCs), consisting of sample locations containing contaminant concentrations three times the ARS, were identified for additional

remediation. Second, several mostly non-vegetated areas were identified (which are areas that can be accessible to trespassers with insufficient vegetation to cover soil) that may contain a contaminant concentration above the ARS remediation goal, which potentially require additional evaluation and remediation. The remedial alternatives presented in this FS include evaluation of potential remedial actions for these areas.

The following five Remedial Alternatives for soil were evaluated in this FS:

- 1) No Action;
- 2) Site Controls (i.e., Institutional Controls, Fencing and Signage);
- 3) Site Controls, Capping of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals;
- 4) Site Controls, Excavation and Off-Site Disposal of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals; and,
- 5) Site Controls and Capping of All Landfill Material.

The following table summarizes each soil Remedial Alternative when compared to USEPA's evaluation criteria in the National Contingency Plan (NCP).

Evaluation Criteria	Soil Remedial Alternatives				
	1	2	3	4	5
<u>Threshold Criteria</u>					
Overall Protection of Human Health and the Environment	NA	<u>Poor to Moderate* Docs Not Meet NCP Criterion</u>	<u>Good to Excellent* Meets NCP Criterion</u>	<u>Good to Excellent* Meets NCP Criterion</u>	<u>Moderate to Excellent* Meets NCP Criterion</u>
Compliance with ARARs	NA	<u>Poor to Excellent* Docs Not Meet NCP Criterion</u>	<u>Excellent Meets NCP Criterion</u>	<u>Excellent Meets NCP Criterion</u>	<u>Excellent Meets NCP Criterion</u>
<u>Primary Balancing Criteria</u>					
Long-Term Effectiveness and Permanence	NA	Poor to Moderate*	Excellent	Excellent	Excellent

Reduction of Toxicity, Mobility, and Volume Through Treatment	NA	Poor	Poor to Excellent*	Poor to Excellent*	Poor to Excellent*
Short-Term Effectiveness	NA	Poor to Excellent*	Good to Excellent*	Moderate to Good*	Poor to Good*
Implementability	NA	Excellent	Excellent	Moderate to Excellent*	Moderate to Excellent*
Costs	NA	\$761,000	\$15,544 16,525,000 to \$21,099,000	\$32,426831.000 to \$57,792,000	\$54,261 55,430,000

NA - Not Applicable

[NCP – National Contingency Plan](#)

For Soil Alternatives 3 and 4, the range of costs reflects differing remedial approaches included within the alternative.

*includes ranges within the sub-categories of the evaluation criteria

The No Action ~~alternative~~Alternative has no remedial components and provides no protection, and therefore it was not compared to the evaluation criteria. Soil Alternative 2, Site Controls, provides some protection to potential trespassers and prevents future use of the Site through institutional controls at a low cost. However, it does not ~~reduce~~meet the ~~low ecological risk identified in the BERA~~, [NCP requirements for protection of human health](#) and ~~does not comply the environment, or for compliance~~ with ~~all~~ ARARs.

Alternatives 3 and 4 remediate the Selected Area of the Site to reduce the overall risk to potential trespassers and to vermivorous birds and mammals, and include remediation of the APCs and mostly non-vegetated areas to further reduce risks. They provide excellent overall protection, comply with ARARs, and provide excellent long-term protection. However, Alternative 3 has better short-term effectiveness because it has fewer impacts to the community, and it is more cost effective than Alternative 4. In addition, due to implementability issues, Alternative 4 becomes less favorable to Alternative 3 as the excavation depth increases.

Alternative 5 is similar to Alternatives 3 and 4 in terms of overall protection, compliance with ARARs, and long-term effectiveness. However, this alternative will have the greatest impact on the community because of the number of trucks needed to import fill material to cap the entire landfill, and because it destroys the existing habitat at the Site, replacing it with a new habitat (~~grasslands~~) that has lower ecological value than the existing well-established mature trees and woody habitat. In addition, Alternative 5 is likely more expensive than any other alternative.

The following three Remedial Alternatives for groundwater were evaluated in this FS:

- 1) No Action;
- 2) Source Control and Monitoring; and,
- 3) Source Control and Monitoring with a Contingent Remedy.

The following table summarizes the characteristics of each groundwater Remedial Alternative when compared to [USEPA's](#) the evaluation criteria [in the NCP](#).

Evaluation Criteria	Groundwater Remedial Alternatives		
	1	2	3
<u>Threshold Criteria</u>			
Overall Protection of Human Health and the Environment	NA or Poor *Does Not Meet NCP Criterion	NA or Good *Meets NCP Criterion	NA or Excellent *Meets NCP Criterion
Compliance with ARARs	NA or Poor *Does Not Meet NCP Criterion	Good to Excellent *Meets NCP Criterion	Excellent Meets NCP Criterion
<u>Primary Balancing Criteria</u>			
Long-Term Effectiveness and Permanence	NA or Poor*	Good	Excellent
Reduction of Toxicity, Mobility, and Volume Through Treatment	Poor	Poor	Good to Excellent*
Short-Term Effectiveness	NA or Poor*	Moderate to Excellent*	Good to Excellent*
Implementability	NA	Good to Excellent*	Good to Excellent*

Evaluation Criteria	Groundwater Remedial Alternatives		
	1	2	3
Costs	\$0	\$1,345,000	\$2,815,000

NA - Not Applicable

[NCP – National Contingency Plan](#)

*includes ranges within the sub-categories of the evaluation criteria

Alternative 1 involves no action, and therefore does not actively improve groundwater conditions relative to ARARs (although naturally occurring reductions have been observed and can be expected to continue to occur).

Alternative 2 includes source control, which is an essential component of most groundwater remedies, and monitoring. It also includes establishment of institutional controls (Classification Exception Area and Well Restriction Area). After source control is implemented, COC concentrations in groundwater will be reduced by ongoing natural processes. The remedial components of Alternative 2 are straight-forward and readily implementable. Long-term monitoring will provide data to evaluate the effectiveness of the source control, the trajectory toward achieving RAOs, and the potential need to make adjustments to the remedy in the future.

Without implementation of the contingent remedy component, Alternative 3 is the same as Alternative 2 in all respects and would have the same relative rating with respect to the [USEPA NCP](#) threshold and balancing criteria. Because it includes a contingent remedy to be implemented if needed based on monitoring results, Alternative 3 is more likely than Alternative 2 to meet chemical specific ARARs, will be more effective, and will reduce toxicity, mobility, and volume of COCs through treatment. Like Alternative 2, Alternative 3 includes long-term monitoring so the effectiveness of the remedy can be assessed, and adjustments can be made, if needed. When the contingent remedy is included, Alternative 3 is approximately twice the cost of Alternative 2.

1. INTRODUCTION

On behalf of Chevron Environmental Management Company for itself and on behalf of Kewanee Industries, Nokia of America Corporation (f/k/a Alcatel-Lucent USA Inc.), and Novartis Pharmaceuticals Corporation (collectively, the Group), Geosyntec Consultants (Geosyntec) has prepared this Feasibility Study Report (FS Report) for the Rolling Knolls Landfill Superfund Site (the Site) in Chatham, New Jersey. The purpose of this FS Report is to evaluate remedial alternatives for soil and groundwater based upon the remedial action objectives (RAOs) for the Site, and to conduct a detailed analysis of these alternatives based upon seven threshold and primary balancing criteria, including effectiveness, implementability, and cost.

The Site location is shown in Figure 1-1, and the Site features are shown in Figure 1-2. The Site was included on the National Priorities List in September 2003. The Group executed the Administrative Settlement Agreement and Order on Consent (Agreement) (Index No. II-CERCLA-02-2005-2034) with the United States Environmental Protection Agency (USEPA) in 2005. Between 2005 and 2007, investigation workplans were prepared and submitted to USEPA for review and approval. Beginning in 2007, the Group conducted field investigation activities in accordance with USEPA-approved work plans.

The remainder of this report includes:

- A discussion of Site conditions and results of Site investigations (Section 2);
- The results of human health and ecological risk assessments (Section 3);
- A summary of the constituents of concern (COCs), a discussion of risk-based and Site use-based evaluations, and the presentation of the Applicable or Relevant and Appropriate Requirements (ARARs), RAOs, and Preliminary Remediation Goals (PRGs) (Section 4);
- The development of soil and groundwater remedial alternatives (Section 5);
- Detailed analysis of the soil remedial alternatives (Section 6);
- Detailed analysis of the groundwater remedial alternatives (Section 7);
- Summary and conclusions (Section 8); and,
- References (Section 9).

2. SITE BACKGROUND

2.1 Site Description

The Site location is shown in Figure 1-1, and the Site features are shown in Figure 1-2. The Site is located at the southern end of Britten Road in the Green Village portion of Chatham Township. Green Village is a scenic, rural village oriented along Green Village Road. Green Village Road is a 2-lane (one in each direction) county road with residential and limited commercial development on each side. Britten Road intersects Green Village Road and is primarily residential. Britten Road is approximately 1.5 lanes wide and is the only road that provides access to the Site. The Site is approximately 5.5 miles from the nearest major road, State Route 24, and is accessible only by driving through residential and commercial areas of Chatham.

The Site is located within the Piedmont Physiographic Province which is characterized by a low rolling plain that is divided by a series of higher ridges. The topography in the vicinity of the Site is approximately 240 feet above mean sea level with minor fluctuation in topographic relief.

The area of the Site where waste disposal occurred covers approximately 170 acres, consisting of 140 acres of landfill with a layer of waste material (18 feet or less in thickness) overlying native soil and an approximately 30-acre area adjacent to the landfill with isolated areas of debris scattered on the ground surface, but with no buried waste, referred to as the Surface Debris Area (Figure 1-2). The landfill was used for disposal of municipal waste from Chatham Township and nearby municipalities from the 1930s to approximately 1968. Landfilled materials were generally consistent with typical municipal solid waste expected within a landfill operating during this period. Evidence of potential industrial waste, identified based on visual observations and analytical results, were observed at three isolated areas, comprising only a small proportion of the total volume of waste disposed of at the landfill. The landfill is covered in some areas by a thin layer of soil and/or vegetation, and in others the waste is visible at the surface. Historical operations of the landfill included the application of pesticides for mosquito and rodent control on the landfill and the surrounding area.

Wetlands occupy the adjacent areas to the east, south, and west of the Site. Loantaka Brook and residential properties are located to the west. Black Brook and the Great Swamp National Wildlife Refuge (GSNWR), including a designated Wilderness Area,

borders the Site to the south and east. Thirty-five acres of the landfill are located within the GSNWR, as discussed below.

The GSNWR was established in 1960 and encompasses 7,768 acres of varied habitats, including wetlands, uplands, and aquatic areas (Fish and Wildlife Service, 2016). The eastern portion of the GSNWR comprises the 3,660-acre Wilderness Area. More than 244 species of birds have been identified at the GSNWR, as well as a wide range of native mammals (for example, river otter, mink, red fox, and opossum), fish, amphibians and reptiles. Several endangered species, including Indiana bat, bog turtle, and blue-spotted salamander are also found at the GSNWR (Fish and Wildlife Service, 2016).

2.2 Current and Future Site Use

Two landscaping companies rent areas on the landfill and the Surface Debris Area for storing equipment and maintenance operations. A small area, known as the laydown area, is located on the portion of the Site owned by the Trust created by the Last Will and Testament of Angelo J. Miele (Miele Trust). The Group has been advised that Paul Miele is the current Trustee of the Trust. This laydown area is currently used by Chatham Disposal and South Orange Disposal, both of which are municipal waste hauling companies owned by members of the Miele family, for the storage and staging of empty 30-yard solid waste roll-off bins. A small building known as the Hunt Club is located on the Surface Debris Area and is used infrequently for social functions. Hunters formerly used the landfill from time to time but are no longer observed. A Shooting Range and Baseball Field are located north of the landfill on land owned by the Green Village Fire Department (GVFD) and are used infrequently for recreation.

Use of the Hunt Club and [the](#) two landscaper areas will not continue when the selected remedy is implemented. The Miele Trust will continue to allow the disposal companies to use a portion of the property that is outside the landfill boundary for a laydown area, to the extent USEPA consents to this use and it will not impact the selection, implementation, or effectiveness of the remedy selected. With the GSNWR located both on and adjacent to the Site, maintenance of the Site in an undeveloped condition provides a buffer between the developed areas of Chatham Township and the GSNWR. The presence of wetlands, the flood hazard area and habitat for state- and federally-listed endangered species severely limits Site use. Accordingly, the environmental characteristics and associated regulatory restrictions and other impediments to development make open space/preservation the likely anticipated future use of the Site (TRC, 2017). The GSNWR is already a preserve and the Group is working to finalize an agreement with the Miele Trust to allow engineering and institutional controls to restrict

use of and access to the portion of the Site that it owns. In accordance with a June 6, 1988 Resolution of the Chatham Township Planning Board pursuant to which the GVFD Lot (Block 48.20, Lot 189.01) was subdivided and created, “no construction, development, improvements or land disturbance” is permitted on any portion of the lot located within the flood hazard area or within that portion of the lot previously used as a landfill operation (Chatham Township Planning Board, 1988).¹ Restriction of access to this area is included in the soil alternatives discussed in following sections. As a result, there will be no residential, commercial, industrial, recreational, or any other use of the landfill portion of the Site.

Based on the results of the RI, the Baseball Field and Shooting Range, while located on GVFD property, were found to be outside the landfill boundary and are not impacted by the waste materials. These areas may be used for recreational purposes in the future.

2.3 Site Ownership

The 170-acre Rolling Knolls Landfill has four owners. A total of 130 acres (100 acres of the central and western portions of the landfill, and the 30-acre Surface Debris Area, both shown on Figure 2-1), are owned by the Miele Trust. A small area at the northern end of the Surface Debris Area, approximately 4,000 square feet but not surveyed, is owned by a private resident of Chatham Township. This small area will be included in the selected soil remedial alternative. Five acres of the landfill are on GVFD property. The GVFD property also includes a Baseball Field and Shooting Range. USEPA included the Baseball Field and Shooting Range as part of the Site for purposes of the Remedial Investigation (RI) and FS, however during the RI both areas were found to be outside the landfill boundary and are not impacted by the waste materials. The remainder of the landfill (approximately 35 acres) is owned by the United States Fish and Wildlife Service (USFWS).

2.4 Site History

The Rolling Knolls Landfill reportedly operated from the 1930s until the late 1960s. The landfill was closed in December 1968. Wastes that were disposed of at the landfill during its operation included primarily municipal solid waste as well as a limited amount of industrial wastes and construction and demolition debris generated by the surrounding municipalities (including: Summit, South Orange, Madison, Harding, Chatham Township, Chatham Borough, Berkeley Heights, Warren, Morristown, Millburn,

¹ These same restrictions also apply to a portion of the landfill property Block 46.20, Lot 189.

Florham Park, Long Hill, New Providence, Maplewood, and the County of Morris). Regulations imposed by the Chatham Township Board of Health (CTBH) during and after the operation of the landfill included requirements for weekly inspections, the application of minimal daily cover (i.e., “swamp muck”), rodent and mosquito control, and drainage of stagnant surface water (Arcadis, 2012). CTBH records also referenced the application of herbicides, oil (as a dust control measure), chemical sprays (for rodent control), the disposal of dead animals, and for a period of time, disposal of septic wastes (Arcadis, 2012).

In 1964, the United States acquired 300 acres of land from the North American Wildlife Federation. A portion of that land was subject to an easement pursuant to which the United States permitted the Miele Trust to conduct sanitary landfilling operations on the acquired property through December 31, 1968. According to the RI (Geosyntec 2018), landfilling operations were conducted on approximately 35 acres of this property, which became part of the GSNWR. In 1969, Chatham Township contacted the United States about its plans to comply with Chatham Township ordinances regarding closure of the landfill (Chatham Township, 1969). The United States responded that “Mr. Miele” and not the United States was responsible for closure and that the United States would contact Mr. Miele and report back to Chatham (United States Department of the Interior, 1969). There is no evidence in the record that this ever happened. A fire occurred at the Site in 1974, and due to accessibility issues in responding to the fire, the Trust was permitted to construct fire roads at the Site, which it did from 1979 to 1982. In January of 1975, Chatham Township again contacted the United States (Letter from the Town of Chatham to Mr. Richard E. Griffith, Regional Director, Fish and Wildlife Service (January 14, 1975; Chatham, 1975). Chatham noted that the portion of the landfill that the United States owned was never properly covered and requested the United States’ plans for final cover and other actions to avoid future fires. In response, the United States acknowledged that the portion of the landfill on its property was never properly closed but advised Chatham that it had no plans to cover the landfill, that covering it might cause more damage than leaving it alone, and with respect to the possible leaching of pollutants from the landfilled waste, “nature should now be allowed to take its course.” The fire roads that the Trust constructed consist of imported material, including construction and demolition debris, and are approximately 4 feet higher than the surrounding landfill surface (Arcadis, 2012).

2.5 Previous Investigations

Contractors to USEPA conducted several investigations at the Site between 1985 and 2003. The work included collection and analysis of soil, sediment, surface water, and fish tissue samples. In addition, these investigations included installation and sampling of seven monitoring wells. Six of these monitoring wells are still in use.

The results of these investigations were used by USEPA in the initial evaluation of the Site. However, they have been superseded by the results of the investigations conducted by the Group since the Agreement was executed.

2.6 Implementation of the Remedial Investigation

The RI was conducted in two major phases. The first phase was planned and implemented from 2005 through 2011, with the general objectives of (1) characterizing the geology and hydrogeology at and in the vicinity of the landfill; (2) characterizing the waste in the landfill including its contents and extent; (3) characterizing COCs in environmental media (soil, sediment, surface water, groundwater, and soil gas) at and in the vicinity of the landfill; and, (4) providing a basis for risk assessments and for remedy selection. The results of the first phase of the RI were reported in the Site Characterization Summary Report (SCSR; Arcadis, 2012).

After the submittal of the SCSR, USEPA and the Group discussed additional work that might be needed to address data gaps at the Site to complete the RI. The overall objectives of the additional work were to (1) complete characterization of the nature and extent of COCs associated with the Site; (2) provide additional information to be used in scoping an evaluation of ecological risk; and, (3) provide additional information to be used in screening remedial alternatives and selecting a remedy for the Site. The results of the second phase of the RI were reported in the Data Gaps Tech Memo (Geosyntec, 2016a).

The Group provided a ~~revised draft~~final RI Report (RIR) to USEPA in January 2018 (Geosyntec, 2018). ~~The USEPA is currently reviewing this revised draft RIR, which EPA approved on July 13, 2018.~~ The Group also conducted a supplemental groundwater investigation to evaluate the efficacy of monitored natural attenuation (MNA) as a remedial action to address constituents in groundwater at the Site. The results of this investigation were provided to USEPA in January 2017 in the Supplemental Groundwater and Baseline Monitored Natural Attenuation Investigation Report (Groundwater MNA Report; Geosyntec, 2017a). USEPA approved this report in October 2017.

The Group conducted a reuse assessment to evaluate Site-specific, reuse-related considerations to identify reasonably anticipated future Site uses. The results of this assessment were provided to USEPA in February 2017 in the Reuse Assessment Report (TRC, 2017a) and supplemented in a Reuse Assessment Addendum provided to USEPA in April 2017 (TRC, 2017b). The Reuse Assessment Addendum concluded that the potential reuse of the Site is severely limited by (1) the presence of extensive and state- and federally-regulated areas that limit development; (2) the environmentally sensitive nature of the surrounding area; (3) state, county, and local planning documents that discourage development in environmentally-sensitive areas away from established centers and focus on protection of the GSNWR; (4) the lack of available infrastructure and associated Site accessibility issues; and, (5) the presence of buried waste which complicates construction and makes it costlier.

The following summary of the RI results is based on information in the ~~draft~~final RIR and in the Groundwater MNA Report.

2.7 RI Results

2.7.1 Soil

Approximately 240 soil samples were collected in shallow soil within and near the landfill footprint. The depths of these soil samples were generally 0.0 to 1.0 feet below ground surface (bgs), but some (approximately 50) were as deep as 2.0 feet bgs if the shallower intervals did not contain enough soil to sample. The soil samples collected from deeper intervals (9 to 10 feet bgs or the 1-foot interval above the water table, whichever was shallower) were used to characterize COCs in subsurface soils. Most were analyzed for full Target Compound List and Target Analyte List (TCL/TAL) constituents. A subset of the samples was also analyzed for dioxins, furans, and polychlorinated biphenyl (PCB) congeners.

Surface and subsurface soil impacts were identified across the landfill, including volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), PCBs, pesticides and inorganic constituents (i.e. metals, most frequently lead and arsenic). In general, the constituents are widespread and their distribution does not suggest a point source or sources, or discrete spills or releases. A few isolated impacts were observed in the Surface Debris Area, in the western portion of the landfill, and along the western and southwestern landfill perimeter. No waste disposal occurred and no landfill-related impacts were observed in soil at the Baseball Field and Shooting Range.

COC levels in soil samples obtained at or adjacent to the edges of the landfill are generally less than applicable New Jersey Residential Direct Contact Soil Remediation Standards (RDCSRS), providing horizontal delineation of the constituents. Except for one location where PCBs were detected at low levels, samples of native soil collected beneath the landfilled materials confirmed that constituents in the landfill are not present in the underlying native soil.

The results of the soil sampling program at the landfill indicate that the primary COCs in soil are arsenic, lead, benzo(a)pyrene, and PCBs. This is based on the number of times a soil sample result exceeded the New Jersey Non-Residential Direct Contact Soil Remediation Standards (NRDCSRS); only arsenic, lead, benzo(a)pyrene, and PCBs were present in more than two shallow soil samples (0 to 1 feet bgs, or in one case 1 to 2 feet bgs) at concentrations above their NRDCSRS.

PCBs were found at the highest concentrations in the shallow soil in the northern portion of the landfill. The highest levels of arsenic and lead both occur at sample location SS-55, which is in this northern area.

Two isolated locations within the Surface Debris Area also contained elevated levels of certain constituents. These include:

- 9,210 milligrams per kilogram (mg/kg) of lead at location POI-14, where battery casings were observed; and,
- 7,900 mg/kg of lead and 33 mg/kg of benzo(a)pyrene are found at location POI-9, where metal drums, metal debris, and a steel tank were observed.

In addition, several other samples noted below had elevated results; all were collected from 0 to 1 feet bgs unless noted otherwise. Samples at and near test pit TP-09 had elevated COC levels. These include: the sample obtained at approximately 4 feet bgs in TP-09, which contained 310 mg/kg of total PCBs; and soil sample SS-109, which contained 118,000 mg/kg of total xylenes (above its NJDEP Impact to Groundwater Soil Screening Level [IGWSSL] and RDCSRS for total xylenes, but less than its NRDCSRS), 5,500 mg/kg of ethylbenzene (above its IGWSSL, but less than its RDCSRS and NRDCSRS), and 1,900 mg/kg of chloroform (above its IGWSSL, RDCSRS and NRDCSRS). As discussed in Section 2.7.3 regarding groundwater, samples from temporary and permanent monitoring wells near test pit TP-09 also had results above Ground Water Quality Standards (GWQS). As discussed in Section 2.7.3 regarding groundwater, samples from temporary and permanent monitoring wells near test pit TP-09 also had results above GWQS.

Three additional locations with elevated soil concentrations are:

- Soil sample TP-34, which consists of potential industrial waste from test pit TP-34, which contained 19,000 mg/kg of bis(2-ethylhexyl)phthalate (above its IGWSSL, RDCSRS, and NRDCSRS). This sample was obtained at a depth of 4 feet bgs;
- Soil sample SS-71, which contained vanadium at a concentration of 6,140 mg/kg (above its RDCSRS and NRDCSRS [vanadium does not have an IGWSSL]); and
- Soil sample SS-103, which contained cadmium at 22,500 mg/kg (above its IGWSSL, RDCSRS, and NRDCSRS). This sample was obtained at a depth of 4 to 5 feet bgs.

2.7.2 Sediment and Surface Water

Surface water and sediment sampling was conducted in 2008, 2014, and 2015 in the on-Site ponds and in Loantaka Brook and Black Brook both upstream and downstream of the Site (Geosyntec, 2018). Surface water and sediment in the ponds and downstream portions of Loantaka Brook and Black Brook exhibit some COCs that are found at the Site, which include PAHs, pesticides, and metals. These COCs, with the exception of several metals, naphthalene, and acetone, are also found in surface water and sediment upstream of the Site. Therefore, their presence in the two streams appears to be related to natural background concentrations, anthropogenic inputs from upstream of the landfill or discharge of groundwater high in trace elements to surface water. With the exception of a low level of dibenz(a,h)anthracene marginally above its New Jersey Surface Water Quality Standard (SWQS), the COCs are not found in the most downstream surface-water and sediment samples, suggesting that the downstream extent of COCs potentially related to the Site, if any, has been defined. Dibenz(a,h)anthracene was also found in some soil samples on the northern portion of the landfill at concentrations above its NRDCSRS. However, these locations are not near any streams and any connection to the minor levels of dibenz(a,h)anthracene in the downstream samples is not evident.

2.7.3 Groundwater

The discussion in this section includes results and conclusions from both the RIR and the approved Groundwater MNA Report. The groundwater zone of interest at the Site is the shallow water-bearing zone comprised of silt and sand located below the landfilled materials, with a maximum depth of approximately 25 feet bgs. Because it is nearest to the potential sources of contamination in the overlying landfilled materials, the groundwater investigation has been focused on this shallow zone. Although the shallow

aquifer is identified by New Jersey as a Class IIA potable aquifer, it is not currently used nor is it practically available for drinking water because under New Jersey Department of Environmental Protection (NJDEP) regulations (N.J.A.C. 7:9D-2.3) potable wells must have a well casing that is at least 50 feet deep. However, the NJDEP's classification still applies to the Site and remediation will be completed to meet the state and federal standards. The clay layer beneath the shallow water-bearing zone is at least 25 feet thick beneath the Site and reportedly more than 100 feet thick in the Site vicinity (Minard, 1967). The clay layer serves as a barrier to the vertical migration of contamination.

Other than inorganic constituents, the RI concluded that concentrations of COCs above their New Jersey GWQS, are localized with no overall dissolved groundwater plume. Four areas of contaminated groundwater were identified in the shallow water-bearing zone. These include:

- Benzene and 1,4-dioxane in the southwestern part of the landfill. These constituents were found in monitoring well MW-3 and some of the nearby temporary well points and are located downgradient of test pit TP-09, where evidence of potential industrial waste was observed (Figure 2-2). The downgradient extent of benzene is defined by monitoring well MW-15, which did not contain benzene. While 1,4-dioxane is present in monitoring well MW-15, it is at a much lower level than in monitoring well MW-3. The decreases in benzene and 1,4-dioxane concentrations from monitoring well MW-3 to downgradient monitoring well MW-15 indicates natural attenuation of these constituents. Certain polycyclic aromatic hydrocarbons (PAHs), including benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene, and certain SVOCs, including 2-methylphenol, bis(2-chloroethyl)ether, and pentachlorophenol were also found in temporary well points in this area. Of these, only bis(2-chloroethyl)ether was also detected in a monitoring well (MW-3).
- Monitoring wells MW-6 and MW-7 within the landfill historically contained 1,4-dioxane above the GWQS. During the most recent round of sampling, completed in September 2016, samples collected from six monitoring wells (MW-3, MW-7, MW-10, MW-15, MW-18, and MW-19) included analysis for 1,4-dioxane using the currently recommended method (Method 8270 with selective ion monitoring [SIM]), resulting in the lowest possible detection levels. This method had not been developed at the time of the RI sampling. Future monitoring events will utilize this method for 1,4-dioxane analysis. As reported in the MNA Report (Geosyntec, 2017a), monitoring well MW-6 could not be sampled in the most recent sampling

event in September 2016 due to an obstruction (the cause of which is unknown) of sand and grout at 4.88 feet below the top of casing; however, the monitoring well MW-7 concentration remained at a similar level as prior sampling events. Monitoring wells MW-10, [MW-18](#) and [MW-19](#) contained 1,4-dioxane at low concentrations above its GWQS. Monitoring wells X-1 and X-2, downgradient of MW-7 did not contain detectable concentrations of 1,4-dioxane, suggesting that the extent of 1,4-dioxane is limited; however, since these samples were not analyzed using Method 8270 SIM, reporting limits were elevated in these samples. Future sampling at these locations will be completed with 8270 SIM analysis to verify the extent of the 1,4-dioxane.

- Freon compounds (including dichlorodifluoromethane and trichlorofluoromethane) in the northwestern portion of the landfill and the Surface Debris Area. These constituents were found in monitoring wells MW-10, MW-18, and certain of the nearby temporary well points, and are located near point of interest POI-10, where refrigerators were observed on the ground surface (Figure 2-2). The downgradient extent of the Freon compounds is defined by two pore-water samples collected in the near-by wetlands. The most recent groundwater sampling event did not detect Freon compounds at concentrations above the GWQS.
- PCBs detected historically at monitoring well MW-7 in the east-central portion of the landfill. PCBs were not detected in nearby and downgradient monitoring wells, so these impacts are confined to this specific area in the immediate vicinity of MW-7. In addition, PCBs were not detected in the most recent sample at this well, collected in September 2016.
- Benzene at monitoring well MW-19 near the southeastern boundary of the landfill. The benzene concentration at MW-19 only marginally exceeds the GWQS. The extent of benzene in this well is defined by two downgradient pore-water samples obtained in the wetlands, which did not contain detectable concentrations of benzene.

Inorganic constituents were ubiquitous in the monitoring well samples. Inorganic constituents are common in groundwater within this region of New Jersey. While it is understood that the landfill may contribute to concentrations of these inorganic constituents in groundwater, discerning between contributions from the landfill and natural background concentrations of these constituents is difficult because the concentrations at the Site are similar to background. Therefore, although some inorganic constituents are present in groundwater at concentrations above their GWQS, their occurrence is widespread and does not suggest a distinctive source or release.

Concentrations of dissolved metals (i.e., the results of filtered samples) are generally much less than the concentrations of total metals. This indicates that most of the metals detected are associated with colloids in the samples. The concentrations of arsenic, iron, and manganese were similar in non-filtered and filtered samples from the same wells. This indicates that most of the arsenic, iron, and manganese in groundwater beneath or near the landfill is in dissolved form, likely because of reducing conditions in the groundwater in the shallow-water bearing zone.

The concentration of metals in the aquifer underneath the landfill are generally highest in the center of the landfill (monitoring wells MW-1, MW-6, and MW-7) and decrease as groundwater flows to downgradient areas (monitoring wells X-3, MW-4, and MW-14). This is likely related to geochemical conditions in the aquifer:

- Strongly reducing conditions beneath the landfill, which leads to the formation of sulfide minerals, and
- Oxidizing conditions outside the landfill, which leads to immobilization of metals in oxidized forms.

2.7.4 Sub-Slab Soil Gas and Indoor Air

Sub-slab soil gas was collected from beneath the Hunt Club building, a small generally unoccupied building that is used occasionally for social functions. The small number of volatile compounds detected in soil gas and their low concentrations below regulatory action levels confirm that soil gas beneath the Hunt Club building is not a potential indoor air threat.

2.7.5 Summary of Conceptual Site Model

The following sections summarize the hydrogeology and contaminant fate and transport portions of the Conceptual Site Model (CSM) presented in the RIR (Geosyntec, 2018).

2.7.5.1 Summary of Hydrogeologic Conditions

Surface water flows from the highest areas near the northern portion of the landfill and the two northern ponds to the east, south, and west. Water in Black Brook, east and south of the landfill, is not channelized but flows by sheet flow to the south and then to the southwest. Loantaka Brook is channelized near the Site and flows to the southwest. There is an area of wetland between the Surface Debris Area and Loantaka Brook that also appears to be subject to sheet flow, parallel to Loantaka Brook.

The northern ponds and the pond south of the Hunt Club building are isolated from Loantaka Brook and Black Brook. They do not have direct surface-water flow into them (other than an ephemeral drainage ditch that contributes surface water from the landfill to the pond south of the Hunt Club building) and are not drained by surface water flow. A culvert that crosses beneath the access road to the west of this pond has been noted, and while no connection has been observed, there is a potential for flow from the pond to the adjacent wooded area during seasonal high-water events.

The hydrostratigraphy underlying the landfill consists of a shallow water table saturated zone, comprised of silt and sand deposits underlain by a layer of glaciolacustrine clay that serves as a confining unit to the geologic formations below. Data from twenty-five monitoring wells have provided significant characterization of the hydrogeologic conditions in this shallow water-bearing zone. Monitoring well screens cross silt, sand and clay deposits, and in some cases, the landfilled materials.

The fill material, silt, and sand deposits are thin compared to the underlying clay. The shallow water-bearing zone includes the saturated portions of the fill, the silt, and the sand deposits above the clay layer, with a total saturated thickness of 15 feet or less.

The depth and extent of saturation of waste material varied widely across the landfill, based on observations during test pit excavation, soil boring advancement and monitoring well installation activities. Dry, moist and wet conditions were observed in the waste material, and the native material beneath the waste was saturated. Test pit excavation logs indicated that the depth to saturation ranged from the ground surface to beneath the waste material (if present) and in some instances saturation was not observed for the entire test pit depth. In areas where the waste material was observed to be saturated at the surface, saturation was likely from precipitation and/or overland flow.

Water likely flows vertically through the waste materials with some small horizontal component, and upon reaching the saturated material below, flows laterally with the natural groundwater flow patterns. Groundwater flow occurs laterally in the shallow water-bearing zone above the clay until reaching areas of discharge. Groundwater in the shallow water-bearing zone flows radially from the northern portion of the landfill to the south, east, and west areas of lower topographic elevation.

The presence of clay at the base of the soil borings and monitoring wells is evidence of the remnant glacial lake. The clay is grey in color with some brown or reddish-brown intervals, cohesive, and plastic, with only a small proportion of silt or fine sand. At the deepest boring (SB-8), the top of the clay was 25 feet bgs and the clay continued to the bottom of the boring at 50 feet bgs with little to no change in its properties. This clay is

continuous beneath the landfill, reported to be more than 100 feet thick and locally as much as 128 feet thick at the east end of the GSNWR (Minard, 1967), and will restrict vertical flow and constituent migration into groundwater below the clay layer, confining the underlying groundwater.

2.7.5.2 Overview of the Constituent Fate and Transport Processes

As previously discussed, the landfill consists of municipal solid waste. Some potential industrial wastes have been identified, but they are small in area and do not comprise a significant portion of the volume of the waste. This is expected based on the historical use of the landfill for disposal of municipal waste from Chatham Township and nearby municipalities. The surface of the landfill in some areas is covered by a thin soil layer and/or vegetation; in other areas, municipal waste is visible at the ground surface.

Precipitation that falls on the landfill either transpires back to the atmosphere, recharges groundwater in the shallow water-bearing zone, or runs off to the neighboring wetlands or surface-water bodies (i.e., the ponds, Loantaka Brook and Black Brook). The shallow groundwater beneath the Site occurs in a thin, sandy and silty material that extends to 15 to 25 feet bgs. The landfill and shallow water-bearing zone are underlain by a thick, continuous, plastic clay unit. RI soil borings indicate that this unit is at least 25 feet thick and literature values indicate that it is more than 100 feet thick and locally as much as 128 feet thick at the east end of the GSNWR (Minard, 1967). This clay unit is a barrier to vertical groundwater flow and constituent migration, protecting the underlying water-bearing material. Given the relatively low levels of constituents in the shallow water-bearing zone beneath the landfill, the nearby availability of surface discharge areas, and the thickness and lack of permeability of the clay, impacts to groundwater beneath the clay unit are not expected.

Surface water and sediment in the ponds and streams (Loantaka Brook and Black Brook) on or adjacent to the landfill exhibit some constituents that are found at the landfill. As such, it is possible that surface water bodies on and adjacent to the landfill receive deposition of eroded material from the landfill containing constituents detected in surface soil samples. Many of the constituents detected in downstream sediment of Loantaka Brook and Black Brook are also found in surface water and sediment upstream of the landfill. Therefore, their presence in the streams is at least in part due to sources upgradient of the landfill. It is also likely that concentrations of lead in some sediment samples (i.e., SW-22, SW-23, and SW-24) may be partially attributed to non-landfill related activities conducted in the shooting range. The results of the semiquantitative comparison of upstream and downstream data and the distribution of exceedances of

SWQSS or Ecologically-Based Screening Levels downstream of the landfill indicate that the downstream extent of constituents related to the landfill, if any, has been defined.

Groundwater in the shallow water-bearing zone flows from the landfill to the surrounding wetlands. This constitutes a potential transport mechanism in the areas where groundwater is contaminated. However, downgradient sampling (either wells or pore-water samples) suggests that migration of COCs is not occurring from groundwater beneath the landfill to the wetlands or surface water bodies outside the landfill.

3. RESULTS OF RISK ASSESSMENTS

3.1 Baseline Human Health Risk Assessment

A Baseline Human Health Risk Assessment (BHHRA; CDM, 2014) was prepared for the Site based on the results in the SCSR. USEPA subsequently evaluated the results of the BHHRA during 2016 to determine the impact of the sampling results obtained after the SCSR and confirmed that the conclusions of the 2014 BHHRA were still valid. The results discussed herein are from the 2014 BHHRA.

The focus of the assessment was to characterize potential exposure, cancer risks, and non-cancer health hazards to potential human receptors at the Site if no remedial actions are taken to address environmental impacts that are present. The objective of the BHHRA is to provide information to support Site-specific risk management decisions when evaluating and selecting remedial action approaches and options. The BHHRA is supported by information included in a *Revised Technical Memorandum on Exposure Scenarios and Assumptions* (MESA) and a *Pathway Analysis Report* (PAR), both of which were approved by the USEPA (Arcadis, 2008 and 2013a). The MESA detailed exposure scenarios, potential receptors and receptor-specific exposure assumptions that were used to evaluate potential human health cancer risk and/or non-cancer health hazards. The subsequent PAR identified chemicals of potential concern (COPCs), Site-specific exposure assumptions, and toxicological data used in the evaluation of potential risks and hazards to receptors at the Site. The resulting BHHRA incorporates Site setting characteristics, exposure scenarios, potential receptors, and receptor-specific exposure assumptions as well as the COPC, Site-specific exposure assumptions, and toxicological data when presenting the characterization of exposure, risk, and possible hazards to potential receptors at the Site. The reader should refer to the BHHRA itself for a complete description of methods and results.

The use of the laydown area for storage and staging of empty solid waste roll-off containers by two municipal waste haulers (Chatham Disposal and South Orange Disposal) was not evaluated in the BHHRA. However, because any on-going use of the laydown area will not occur on an area located on the landfill, no exposure to contaminants by any user of the laydown area will occur. Therefore, an exposure assessment for the laydown area is not required.

3.1.1 Exposure Assessment

The BHHRA evaluated two exposure scenarios: the Current and Reasonably Anticipated Future Exposure Scenario and the Future On-Site Residential Exposure Scenario.

Current and Reasonably Anticipated Future Use Scenario

Receptors in the current and reasonably anticipated future exposure scenario with potentially complete exposure pathways include:

- A landscaper in Landscaper Area 1
- A landscaper in the Hunt Club Area and Landscaper Area 2
- A Hunt Club user at the Hunt Club and Landscaper Area 2
- An adolescent and/or adult shooting range user at the Shooting Range
- A ball player on the Baseball Field
- An adolescent and/or adult trespasser on the Landfill
- An adolescent and/or adult hunter on the Landfill

Future On-Site Residential Development Scenario

Although it did not characterize residential development as a reasonably anticipated future use, the BHHRA evaluated the following receptors with potentially complete exposure pathways should the future Site use include a residential development: 1) a child and/or adult resident in the potentially developable area (defined as the landfill areas outside the GSNWR, potential bog turtle habitat, potential wetlands and related transition area, and potential FHA); and, 2) a construction worker in the potentially developable area. If the zoning of the Site is modified to exclude residential development, or if use restrictions prohibit future residential development, this exposure scenario is no longer relevant.

3.1.2 BHHRA Results

Potential health risks to receptors in each exposure scenario were quantified for cancer risk, non-cancer health hazard and lead exposure. The risk characterization results are as follows:

Current and Reasonably Anticipated Future Exposure Scenario

Receptors	Cumulative Cancer Risk		Cumulative Non-Cancer Health Hazard			
	RME ¹	CTE ²	RME	Target Organ HIs ³ > 1	CTE	Target Organ HIs > 1
Landscaper (Landscaper Area 1)	6x10 ⁻⁵	1x10 ⁻⁵	2	None	1	None
Landscaper (Hunt Club & Landscaper Area 2)	5x10 ⁻⁶	1x10 ⁻⁶	0.1	None	0.09	None
Hunt Club User (Hunt Club & Landscaper Area 2)	2x10 ⁻⁶	3x10 ⁻⁷	0.04	None	0.02	None
Adolescent Shooting Range User (Shooting Range)	5x10 ⁻⁸	4x10 ⁻⁸	0.002	None	0.002	None
Adult Shooting Range User (Shooting Range)	1x10 ⁻⁷	3x10 ⁻⁸	0.003	None	0.003	None
Ball Player (Baseball Field)	2x10 ⁻⁷	5x10 ⁻⁸	0.002	None	0.002	None
Adolescent Trespasser (Landfill)	8x10 ⁻⁵	1x10 ⁻⁵	6	Eye, Immune System, Nails	0.9	None
Adult Trespasser (Landfill)	1x10 ⁻⁴	6x10 ⁻⁶	4	Eye, Immune System, Nails	0.7	None
Adolescent Hunter (Landfill)	4x10 ⁻⁶	3x10 ⁻⁶	0.4	None	0.3	None
Adult Hunter (Landfill)	9x10 ⁻⁶	2x10 ⁻⁶	0.3	None	0.2	None

Notes

1 RME – Reasonable Maximum Exposure

2 CTE – Central Tendency Exposure

3 HIs – Hazard Indices

Individual constituent and cumulative Reasonable Maximum Exposure (RME) and Central Tendency Exposure (CTE) cancer risk and non-cancer health hazard estimates for adolescent and adult shooting range users at the Shooting Range and the ball player at the Baseball Field are less than USEPA target values (cancer risk of 1x10⁻⁴ to 1x10⁻⁶ and non-cancer health hazard of unity [1]), and therefore, are considered negligible.

Individual constituent and cumulative RME and CTE cancer risk estimates for the landscaper in the Hunt Club/Landscaper Area 2, the Hunt Club user in the Hunt

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Club/Landscaper Area 2, and adolescent and adult hunters on the landfill are within or less than the USEPA range of acceptable risks. Individual constituent and cumulative RME and CTE non-cancer health hazard estimates for these receptors are less than the USEPA target value of 1, and therefore, are considered negligible.

Individual constituent and cumulative RME and CTE cancer risk estimates for the landscaper in Landscaper Area 1 are within the USEPA range of acceptable risks. The cumulative RME non-cancer health hazard estimate for the landscaper in Landscaper Area 1 is slightly greater than the target value of 1; however, individual target organ hazard indices (HIs) for this receptor are each less than or equal to 1. Therefore, potential hazards to this receptor are likely negligible. In addition, individual and cumulative CTE non-cancer health hazard estimates for this receptor are less than the target value of 1.

Individual constituent and cumulative RME and CTE cancer risk estimates for the adolescent and adult trespassers are within the USEPA range of acceptable risks. Individual and cumulative RME and CTE non-cancer health hazard estimates for the adolescent and adult trespassers on the landfill in the Current and Reasonably Anticipated Future Exposure Scenario are greater than the USEPA target level. PCBs are the non-cancer health hazard drivers for these receptors.

Potential exposure of receptors in the Current and Reasonably Anticipated Future Exposure Scenario to lead² was evaluated using the USEPA Adult Lead Methodology (ALM).

Exposure Scenarios and PbB Receptors	Lead Model	Probability of Exceeding the Estimated Probability of Fetal Blood Lead Concentration of 10 µg/dl
Landscaper (Landscape Area 1)	ALM	0.5%
Adolescent Trespasser (Landfill)	ALM	3%
Adult Trespasser (Landfill)	ALM	3%

µg/dl – micrograms per deciliter

² Note that USEPA is updating the BHHRA to incorporate new guidance for the assessment of risks associated with lead.

The estimated probability of fetal blood lead concentration (PbB) exceeding the target PbB is less than 5 percent for the landscaper in Landscaper Area 1 and adolescent and adult trespassers on the landfill. Potential adverse health effects associated with exposure to lead for these receptors are thus not expected.

Lead was not identified as a COPC at the Hunt Club Area and Landscaper Area 2, the Shooting Range or Baseball Field, so receptors in these human use areas were not evaluated for potential lead exposure. Furthermore, exposures to adolescent and adult hunters on the landfill are assumed to occur for only a 1-week period during hunting season in December of each year. Therefore, it is assumed that PbB in these receptors do not reach steady state (i.e., lead is cleared from the blood following brief exposure). Potential adverse health effects associated with exposure of lead to adolescent and adult shooting range users, ball player, and adolescent and adult hunters is not expected.

Future On-Site Residential Development Exposure Scenario

Individual and cumulative RME and CTE cancer risk estimates for the child resident are greater than the upper end of the USEPA range of acceptable risks (1×10^{-6} to 1×10^{-4}), and individual and cumulative RME and CTE non-cancer health hazard estimates for this receptor are greater than the USEPA target value of 1. Individual and cumulative RME and CTE cancer risk estimates for the adult resident are greater than the upper end of the USEPA range of acceptable risks (1×10^{-6} to 1×10^{-4}), and individual and cumulative RME and CTE non-cancer health hazard estimates for this receptor are greater than the USEPA target value. Cancer risk and non-cancer health hazard drivers are PAHs, dieldrin, PCBs, dioxins and furans, and inorganics (antimony, arsenic, iron, thallium, and vanadium) in soil and benzene, dichlorodifluoromethane, 1,4-dioxane, vinyl chloride, PAHs, bis(2-chloroethyl)ether, pentachlorophenol, and inorganics (arsenic, iron, manganese, and thallium) in groundwater.

Residential exposure can be expressed as a lifetime exposure of 30 years. When adult residential exposures (estimated for 24 years) and child residential exposures (estimated for 6 years) are summed together to evaluate a potential residential lifetime exposure, the estimated cumulative residential lifetime RME excess lifetime carcinogenic risk (ELCR) is 3×10^{-3} , which is greater than the upper end of the USEPA range of acceptable risks. When summed, the estimated cumulative residential lifetime CTE ELCR is 1×10^{-3} .

Individual and cumulative RME and CTE cancer risk estimates for the construction worker in the Potentially Developable Area are within the USEPA range of acceptable

risks, and individual and cumulative RME and CTE non-cancer health hazard estimates for this receptor are greater than the USEPA target value. Non-cancer health hazard drivers are PCBs and cadmium in surface and subsurface soil.

Potential exposure to lead of a future child resident in the Potentially Developable Area was evaluated using the USEPA Integrated Exposure Uptake Biokinetic model. The resulting probability distribution may be interpreted as an 81 percent probability of exceeding the PbB threshold of 10 µg/dl for a future child resident in the Potentially Developable Area. Potential exposure to lead of a construction worker in the Future On-Site Residential Development Exposure Scenario was evaluated using the USEPA ALM. The estimated probability of the construction worker's fetal PbB exceeding the target PbB of 10 µg/dl is 17 percent. Both scenarios exceed the USEPA risk reduction goal of 5 percent for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites.

[USEPA issued an update to the BHHRA on July 5, 2018 \(USEPA, 2018\). This update addressed: \(1\) exposure frequency; \(2\) toxicity information; and, \(3\) lead levels. No changes to the conclusions of the June 2014 BHHRA resulted from this update.](#)

3.1.3 BHHRA Summary

Estimated cancer risks to all receptors and non-cancer health hazard to the majority of receptors in the Current and Reasonably Anticipated Future Exposure Scenario are within or less than USEPA target levels. The estimated non-cancer hazard to the landscaper in Landscape Area 1 is slightly greater than the USEPA target level, but HIs for individual target organs are all less than or equal to the USEPA target level of 1. Estimated non-cancer health hazard to the adolescent and adult trespassers on the landfill in the Current and Reasonably Anticipated Future Exposure Scenario are greater than the USEPA target level. Estimated cancer risks and non-cancer health hazards to receptors in the Future On-Site Residential Development exposure scenario are greater than USEPA target levels.

The estimated probability of fetal PbB exceeding the target PbB is less than 5 percent for the landscaper in Landscape Area 1, and for adolescent and adult trespassers on the landfill. As such, potential adverse health effects associated with exposure to lead by these receptors are not expected (CDM, 2014).

Overall, carcinogenic ELCRs and non-carcinogenic HIs presented in the BHHRA are based upon conservative assumptions that are intended to be protective of human health

by overestimating exposure to account for parameter uncertainty. Therefore, overall confidence in the risk assessment is high.

3.2 Baseline Ecological Risk Assessment

A Baseline Ecological Risk Assessment (BERA; Integral, 2016a) was prepared for the Site and is based on results available through August 2016. The draft BERA report was submitted to USEPA in September 2016 and revised in accordance with USEPA comments and resubmitted to USEPA on December 28, 2016. USEPA approved the BERA by email dated December 29, 2016. The remainder of this subsection summarizes the results of the BERA (Integral, 2016a).

The objective of the BERA was to assess potential risks to ecological receptors from exposure to Site-related COCs present in environmental media at the Site. The BERA relied on the analytical results of the previous investigations. Supplemental sampling designed to support the BERA was conducted in May and June 2016. This 2016 sampling included collecting sediment samples for bioavailability evaluation and acute toxicity testing, collecting biota representative of forage or prey items for the evaluated receptors, and collection of environmental media from an off-Site reference pond. An ecological habitat assessment was also performed at representative portions of the Site.

The BERA is the final three steps of the eight-step process defined in the *Ecological Risk Assessment Guidance for Superfund* (ERAGS). This phased approach includes increasingly sophisticated levels of data collection and analysis. The BERA builds on two prior documents: the *Screening Level Ecological Risk Assessment* (SLERA; Arcadis 2013b) which provided ERAGS Steps 1 and 2, and the *BERA Work Plan* (Integral, 2016b), which addresses ERAGS Steps 3 through 5.

3.2.1 BERA Methods

The chemicals of potential ecological concern (COPECs) were identified as part of ERAGS Step 3 in the *BERA Work Plan*. Media were screened independently and an aggregated collection of COPECs across all sampled media was developed. These included several SVOCs (e.g., PAHs, phthalates), PCBs, dioxins and furans, and several inorganics. The COPECs include chemicals related to Site use and others that are present naturally in the environment (e.g., metals).

Thirteen assessment endpoints were evaluated in the BERA, including:

- Terrestrial vegetation;
- Benthic invertebrates;
- Amphibians and reptiles;
- Vermivorous birds;
- Vermivorous mammals;
- Piscivorous birds;
- Piscivorous mammals.
- Herbivorous birds;
- Herbivorous mammals;
- Insectivorous birds;
- Insectivorous mammals;
- Carnivorous birds; and,
- Carnivorous mammals.

Empirical data for the COPECs from on-Site sampling were available for surface water, sediments, soil, soil invertebrates (earthworms and centipedes/millipedes), forage fish, tadpoles and aquatic vegetation. COPEC concentrations for aquatic invertebrates, emergent insects, and terrestrial vegetation were estimated using literature uptake factors (sediment or soil to biota). The use of uptake factors from literature sources is conservative and overestimates the potential exposure (and calculated risk) because it does not reflect Site-specific bioavailability from the soil or sediment. Risks were evaluated on a Site-wide basis, by basic habitat types (terrestrial, wetland, or aquatic) and by sub-habitat areas (e.g., West Pond #1, southern wetland).

3.2.2 BERA Results

The BERA results for each receptor are discussed below. The hazard quotient (HQ) was calculated based on Toxicity Reference Values (TRVs) used to assess potential risks for all receptors other than terrestrial vegetation, benthic invertebrates, and amphibians and reptiles. The approach taken for each of these receptors is explained with their results.

Terrestrial Vegetation: The SLERA showed that plant toxicity-based soil benchmarks were exceeded throughout the Site. However, the BERA established that the SLERA may have overestimated the potential risks to plants, since there was little apparent impact to vegetation that can be related to soil COPEC concentrations based on the ecological habitat survey results. The more relevant factors affecting the presence of terrestrial vegetation were (1) the thickness of the soil layer, and (2)

whether solid waste was present on the surface. There were several areas of the Site, predominantly within the perimeter wetlands, that are high-value habitats, such as those associated with potential bog turtle habitats. *Phragmites* stands were noted at several locations within and adjacent to the Site and appear to be invading some of the potential bog turtle habitats. Based on the results of the BERA there is no unacceptable risk to terrestrial vegetation from COPECs.

Benthic Invertebrates: There is a potential risk to benthic invertebrates based on the comparison of the measured sediment concentrations to conservative sediment benchmarks at some of the locations sampled in 2016. This was highly variable; for example, at one of the West Pond #1 locations, total DDX and nine metals had HQ_{sed} (HQ for sediment) values greater than 1, but the remaining two samples had only one COPEC (selenium) with an HQ_{sed} greater than 1. The COPEC metal risks may be overestimated based on the assessment of the sediment bioavailability using the measured simultaneously extracted metals-acid volatile sulfide [SEM-AVS]/total organic carbon (TOC). This showed that potential for sediment toxicity is unlikely at these locations, except for one location at the eastern landfill perimeter at sample SED007. This sample also had the largest mean HQ_{sed} of the evaluated sediments. This sample was also not evaluated for acute toxicity using *Hyalella* and chironomid bioassays, so the potential for toxicity at this location cannot be verified empirically. As discussed in Section 5.1.2 of the BERA, however, there were no statistically significant correlations between any of the organic or inorganic COPEC results or physicochemical parameters (i.e., pH, grain size) with the *Hyalella* or chironomid growth test results. Thus, the exceedance of sediment criteria alone is not a good predictor of toxicity. Given the isolated exceedances for this location, further evaluation of sediment remediation was not needed for the FS.

For all tested locations, acute toxicity using *Hyalella* and chironomid bioassays showed no impacts on survival and only a slight potential impact on *Hyalella* and chironomid growth in one of the three samples from West Pond #1 and in both North Ponds. The difference in *Hyalella* growth relative to the Reference Pond was less than 20%, which is not considered to be significant. There was no correlation between the *Hyalella* and chironomid growth results (absolute values) to the COPEC concentrations, which implies that these effects are likely unrelated to the COPEC concentrations. Thus, there are no unacceptable risks to these receptors.

Amphibians and Reptiles: The potential risks to amphibians were evaluated by comparing observed results to sediment benchmarks, similar to one of the

measurement endpoints used to evaluate benthic invertebrates. Because tadpoles were observed at many of the locations (including those locations which had COPEC concentrations above sediment screening benchmarks, such as the North Ponds), and calls by adult frogs were heard throughout the field program it suggests that there is less likelihood of toxicity to these receptors, particularly at the population-level.

The risk characterization for the amphibians and reptiles also included a comparison to studies that evaluate the potential linkage(s) between sediment PCB concentrations and amphibian population effects. Generally, there is no conclusive linkage between sediment PCB concentrations and amphibian population effects, except possibly at sites with far greater average PCB concentrations in their sediments than what is observed at the Site. Based on this comparison, in conjunction with the lack of correlation between sediment toxicity (generally regarded as a more sensitive receptor than amphibians) and PCB levels in sediments, it is concluded PCBs present in the sediments at the Site do not present an unacceptable risk to amphibians and reptiles.

Vermivorous Birds and Mammals: The BERA indicates that there were HQ_{LOAEL} (HQ for the lowest observable adverse effect limit) values greater than 1 for vermivorous birds (e.g., American robins) and mammals (e.g., short-tailed shrew) that consume soil invertebrates at the Site. This risk was due chiefly to the measured metals and PCB concentrations in the soil invertebrates. The Site total PCB concentrations in soil were lower than those reported from field studies that showed no dose-response relationship between the soil (and prey) total PCBs and population metrics. This suggests that the total PCBs in the Site media may not be causing significant risks to these receptors.

Use of field-collected prey items reduces the potential to overestimate potential exposures and risks to these receptor groups. In addition, conservative assumptions were employed where applicable to minimize the potential for risk underestimation.

Piscivorous Birds and Mammals: The BERA indicates that there is no risk to piscivorous birds (e.g., great blue heron) and a potential minimal risk to piscivorous mammals (e.g., mink) that consume the forage fish or tadpoles from the On-Site Ponds (the HQ_{LOAEL} values were less than one for the individual ponds). None of the COPECs had HQ_{LOAEL} or HQ_{NOAEL} (HQ for no observed adverse effect level) values greater than one on a site-wide basis; or, for the On-Site Ponds (individual ponds or combined) for piscivorous birds. None of the COPEC PAHs, pesticides,

Toxic Equivalency Quotients, or PCB results had HQ_{LOAEL} values greater than 1 for site-wide evaluation; or, for any of the evaluated subareas. Two COPEC metals (copper and selenium) had calculated HQ_{LOAEL} values greater than 1 only on a site-wide basis for piscivorous mammals.

Use of field-collected prey items reduces the potential to overestimate potential exposures and risks to these receptor groups. In addition, conservative assumptions were employed where applicable to minimize the potential for risk underestimation.

Herbivorous Birds and Mammals: There is no potential risk to herbivorous birds (e.g., mallard ducks) and minimal risk to herbivorous mammals (e.g. meadow vole) based on the exposure assumptions and media concentrations that have been used for this assessment. The potential risk to the meadow vole was due chiefly to the mercury, selenium and polychlorinated dibenzo-p-dioxin/furan toxic equivalent quantity (PCDD/F-TEQ) concentrations in prey items of vole. However, the selenium risks are unlikely to be Site related because all of the Site HQ values were comparable to or less than those calculated for the reference areas.

Empirical data on aquatic vegetation and estimated concentrations in aquatic invertebrates were used to assess the potential risks to the mallard ducks. Empirical data on soil invertebrates and estimated concentrations in terrestrial vegetation were used to assess the potential risks to the meadow voles and thus the risk is likely overestimated.

Insectivorous Birds and Mammals: There is no potential risk to insectivorous birds (e.g., tree swallow) and minimal potential risk to mammals (e.g., bats) at the Site. Exposure was predominantly from the consumption of emergent insects, whose tissue levels were estimated using bioaccumulation models. The models assume 100% bioavailability from the sediments, which is unlikely based on the elevated TOC (for organics) and reduced bioavailability for metals based on the (SEM-AVS)/TOC results.

HQ_{LOAEL} values for little brown bat were less than 1 across most of the Site areas, except for arsenic, barium, and methyl mercury in Wetland-east, and copper on a Site-wide and wetland-combined basis (the individual subareas were all below 1). Selenium risks do not appear to be Site-related because larger HQ_{LOAEL} values were calculated in the reference areas than on-Site.

The evaluation of these receptors is the most uncertain relative to the other receptors evaluated in this BERA because of the lack of available empirical data on the principal prey group and the assumption of 100% bioavailability from Site media in the bioaccumulation models used to estimate prey item COPEC concentrations.

Carnivorous Birds and Mammals: There is no potential risk to carnivorous birds (e.g., red-tailed hawk) and mammals (e.g., red fox) at the Site. Exposure was predominantly from the consumption of small mammals, whose tissue levels were measured.

The spatial analysis of the soil analytical data showed that the COPEC concentrations were generally higher in the terrestrial portions of the Site compared to the wetland areas. The biota data were also variable from both the terrestrial and wetland areas (fewer samples were collected from the latter) but on average there were no significant differences between the mean biota concentrations across these habitats for most of the COPECs.

3.2.3 BERA Summary

The results of the BERA indicate that exposures to COPECs in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors and that there is low potential for risk to vermivorous birds and mammals from exposure to metals and PCBs based on food chain models for the short-tailed shrew and American robins. The exposure assumptions and uptake factors used to estimate aquatic invertebrate and emergent insect COPEC concentrations, and the TRVs used to assess the potential ecological risks, include some degree of uncertainty. Uncertainties are inherent for any BERA; however, the nature and magnitude of the uncertainties depend upon knowledge regarding the use of the Site by receptors, the amount and quality of data available and assumptions used in exposure potentials and benchmarks used to assess the potential risks. Here, multiple conservative assumptions were intentionally used to take uncertainties into account. The more conservative the assumptions, the less likelihood that a HQ greater than 1 indicates an unacceptable risk. Accordingly, any uncertainty in this analysis would overestimate rather than underestimate potential risks, given that conservative assumptions were employed where applicable to minimize the potential for risk underestimation.

4. REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

4.1 Calculation of Alternative Remediation Standards

The RDCSRs and NRDCSRs are based upon either a residential or non-residential exposure scenario, neither of which reflects the anticipated future use of the Site, assuming planned institutional controls are implemented. To address this situation, the NJDEP allows site-specific Alternative Remediation Standards (ARSs) to be calculated (N.J.A.C. 7:26D; NJDEP, 2017). These calculations are conducted by replacing NJDEP default exposure factors with exposure factors more reflective of anticipated Site use, in this case, exposure to adolescent and adult trespassers. Based on these calculations, ARSs were developed for 21 COCs in the landfill, two COCs in the Shooting Range, and one COC in the Baseball Field. These ARSs replace the NRDCSRs [and the RDCSRs](#) previously applied to these COCs. The development of the ARSs is discussed in detail in Appendix A.

4.2 Constituents of Concern

For this analysis, chemical constituents were considered COCs if (1) they were present at a concentration that was associated with unacceptable risk in the BHHRA or in the BERA, or (2) they were present at concentrations above an applicable remediation standard in a medium where the risk assessments identified unacceptable risk. COCs were identified in soil and groundwater, but the risk assessments did not identify any potential risks in surface water and sediments, so no COCs have been identified for those media.

4.2.1 Soil

Analytical results in soil were compared to the NRDCSRs and, if the NRDCSR was exceeded, the ARSs. The following COCs have been identified.

Area	COCs	Potential Exposure Pathways
Landfill surface	Metals ¹ , PCBs, PAHs ² , pesticides ³ , SVOCs ⁴	Direct contact (human and ecological)
Surface Debris Area	Lead	Direct contact (human)

Notes:

1 – Aluminum, antimony, arsenic, cadmium, copper, lead, vanadium

2 – Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene

3 – Aldrin, chlordane, dieldrin, heptachlor, heptachlor epoxide

4 – Acetophenone

Metals, PCBs, PAHs, and pesticides were found at concentrations above the NRDCSRs and/or the ARS in surface soil samples (generally collected at no deeper than 1.0 foot bgs) on the landfill. The metals found most frequently at concentrations above their NRDCSRs and/or ARSs were lead and arsenic. The soil COCs are present over most of the landfill but are generally not found in the adjacent soil off the landfill.

Soil results were also compared to the NJDEP's IGWSSLs. IGWSSLs are screening levels intended to identify areas where COCs in soil could migrate to and impact groundwater. (Geosyntec, 2018, Remedial Investigation Report, Section 4.5.4.). They are not duly promulgated regulatory standards, and thus, are not ARARs, but, rather are TBCs (To Be Considered). Concentrations of certain VOCs, SVOCs, pesticides, PCBs, and metals in soil samples exceed their default IGWSSLs. Groundwater results from the existing monitoring well network indicate that there has been limited migration of these constituents to groundwater. In addition, groundwater exceedances do not generally correlate with soil results above IGWSSLs. Therefore, no additional COCs were identified based on the IGWSSLs.

Risks for adolescent and adult trespassers on the landfill in the Current and Reasonably Anticipated Future Exposure Scenario are greater than the USEPA target level. In addition, risks for landscapers in Landscaper Area 1 are slightly above the USEPA target level; however, the use of the property by landscapers will cease upon completion of the selected remedial alternative.

Because future use at the Site is not anticipated to include residential development, risks associated with the Future On-Site Residential Development Exposure Scenario in the BHHRA were not considered in this analysis.

As indicated above, COCs are generally not found in soil samples collected off the landfill. The exception is lead, which is found in several wetlands soil and sediment

samples west of the landfill, in the Surface Debris Area and between the Surface Debris Area and Loantaka Brook. Although lead concentrations exceed its NRDCSRS, no unacceptable risks were found related to lead in this area in either the BHHRA Current or Reasonably Anticipated Future Use Scenario, or in the BERA. The lead concentrations are below the calculated ARS, ~~with the exception of~~ except for soil samples collected at locations POI-9 and POI-14.

4.2.2 Groundwater

Analytical results in groundwater from the shallow water-bearing zone were compared to the GWQS. The following COCs have been identified.

Area	COCs	Potential Exposure Pathways
MW-3 area (southwest portion of landfill)	Benzene, 1,4-dioxane, PAHs ¹ , SVOCs ²	No current risk of exposure.
MW-6 area (central portion of landfill)	1,4-dioxane	No current risk of exposure.
MW-7 area (east-central portion of landfill)	PCBs	No current risk of exposure.
MW-10 and MW-18 area (northwest portion of landfill)	Dichlorodifluoromethane, trichlorofluoromethane, benzene, 1,4-dioxane	No current risk of exposure.
MW-19 (adjacent to southeast portion of landfill)	Benzene	No current risk of exposure.
All areas of landfill	Metals ³	No current risk of exposure.

Notes:

1 – Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene

2 – 2-Methylphenol, bis(2-chloroethyl)ether, pentachlorophenol

3 – Aluminum, antimony, arsenic, beryllium, cadmium, iron, lead, manganese, nickel, sodium, thallium, total cyanide, zinc

There are no potable supply wells at or near the Site. The Hunt Club supply well (designated HC-1) is screened well below the clay layer that mitigates or prevents

migration from the shallow groundwater that is of interest at the Site. The well is not used for drinking water and will be closed in accordance with NJDEP regulations before the selected remedy is implemented. Therefore, there is no current risk of exposure to contaminated groundwater at or near the Site. Any future use of the groundwater is unlikely, and not reasonably anticipated, since New Jersey regulations require drinking water wells to have casings that are at least 50 feet deep (N.J.A.C. 7:9D-2.3). However, the NJDEP's classification still applies to the Site and the goal of remediation is to meet the state and federal standards.

Other than metals, the other COCs in groundwater appear to be in separate, relatively restricted areas. Certain COCs are present at levels that only marginally exceed their GWQS; including:

- bis(2-chloroethyl)ether at wells MW-3;
- 1,4-dioxane at wells MW-6 and MW-10; and,
- indeno(1,2,3-cd)pyrene at well MW-7.

Based on the observed concentrations, the extent of these COCs is likely limited.

Metals in groundwater are Site-wide. As discussed in Section 2.7.3 and in the Groundwater MNA Report (Geosyntec, 2017a), metals are not detected in most of the filtered groundwater samples, indicating that metals concentrations are present in colloidal fractions, which are not readily transported with groundwater. The concentration of metals in the aquifer underneath the landfill are generally highest in the center of the landfill (for example: MW-1, MW-6, and MW-7) and decrease as groundwater flows to downgradient areas (for example: X-3, MW-4, and MW-14). This is related to the geochemical conditions in the aquifer: strongly reducing beneath the landfill, leading to the formation of sulfide minerals, and oxidizing outside the landfill, leading to immobilization of metals in oxidized forms.

4.3 Calculation of Risk-Based Remediation Area for Soil

Based on evaluation of the soil COCs and associated human health risk assessment findings, non-dioxin-like PCBs were determined to be the primary risk driver at the Site and the only risk driver for human health for the trespasser scenario. An evaluation of the PCB data was performed using statistical analysis to identify which area(s) of the Site required remediation to reduce the overall risk at the Site to acceptable levels. The analysis identified that the Selected Area, an approximately 25-acre area on the northern

portion of the Site, requires remediation. The analysis and its conclusions are discussed in detail in Appendix B.

A separate analysis was conducted to verify that the remedial options evaluated in the FS also reduced the low potential risk identified in the BERA for ecological receptors. The analysis evaluated reduction of risks from PCBs, metals, and other COPECs to vermivorous birds and mammals relative to the results presented in the BERA. A combination of quantitative and qualitative approaches was used to evaluate residual ecological risk. For the quantitative evaluation, residual risk was calculated using predicted post-remedy exposure point concentrations (EPCs) along with exposure and toxicity assumptions presented in the BERA (Integral 2016). Residual risks were compared to baseline risks to determine risk reduction (as reflected in a decrease in the calculated HQ of the alternatives). For the qualitative evaluation, residual risk under these alternatives was evaluated in the context of the uncertainty in the exposure calculations (e.g., conservative plant uptake factors) and toxicity benchmarks (e.g., comparison of toxicity reference value [TRV] used for risk calculations relative to range of effect levels), observations of the ecological conditions at the Site, and reference area conditions. The results of the analysis are discussed for the alternatives in Section 6. A complete description of the methods, results, supporting data, and conclusions are discussed in detail in Appendix C.

4.4 Applicable or Relevant and Appropriate Requirements

ARARs are summarized in Table 4-1. ARARs are defined as follows:

“Applicable requirements are federal or state requirements that ‘specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site’ (National Contingency Plan [NCP] Sec 300.5). Relevant and appropriate requirements are federal or state laws that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site, ‘address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to a particular site’ (NCP Sec. 300.5).” (USEPA, 1991).

The three types of ARARs are: chemical-specific, location-specific, and action-specific. These designations are noted for each ARAR in Table 4-1.³

Table 4-1 also identifies certain guidance or other documents that “may provide useful information or recommend procedures if (1) no ARAR addresses a particular situation, or (2) if existing ARARs do not provide protection” (USEPA, 1991). These documents are designated TBCs in Table 4-1.

4.5 Preliminary Remedial Action Objectives

Based on the considerations of Site conditions, results of the risk assessments, the reuse assessment and ARARs described in this section, the following RAOs have been developed for the Site.

1. Prevent or minimize current and potential future unacceptable risks to current and potential future human and ecological receptors through direct contact or ingestion of contaminated soil.
2. Control or remove source areas to prevent, to the extent practicable, impacts to groundwater.
3. Prevent to the extent practicable current and potential future unacceptable risks to human receptors through ingestion of contaminated groundwater.
4. Restore groundwater to its expected beneficial use to the extent practicable by reducing contaminant concentrations below the more stringent of federal Maximum Contaminant Levels, New Jersey GWQSSs, and New Jersey Maximum Contaminant Levels.

4.6 Preliminary Remediation Goals

The PRGs to address human health exposure above USEPA target levels applicable to the Site are listed below by media, with the numeric criteria provided in the below referenced tables. PRGs were not developed for ecological exposures. However, as discussed in Section 4.3, a residual ecological risk evaluation was conducted to evaluate

³ As described in a letter from Walter Mugdan of USEPA to Irene Kropp of NJDEP, dated 12 May 2010, New Jersey’s Soil Remediation Standards (SRS, including both the residential and non-residential scenarios) for direct contact (i.e., ingestion/dermal exposure) are potential ARARs, but will not be considered as ARARs if those standards are not generally applicable, but rather, can change on a site-by-site basis (USEPA, 2010).

how remedial alternatives based on the human health PRGs for soil will also reduce ecological risk (Appendix C) to meet the RAOs.

Soil

- Landfill area: The potential PRGs for this area are shown in Table 4-2. Based on the detected analytes and the calculation of ARSs for 21 compounds, the PRGs for this area are shown in Table 4-3;
- Baseball Field area: The potential PRGs for this area are shown in Table 4-4. Based on the detected analytes and the calculation of ARSs for one compound, the PRGs for this area are shown in Table 4-5; and,
- Shooting Range area: The potential PRGs for this area are shown in Table 4-6. Based on the detected analytes and the calculation of ARSs for two compounds, the PRGs for this area are shown in Table 4-7.

Groundwater

The potential PRGs for Site-wide groundwater are the NJDEP's GWQS as shown on Table 4-8. Based on the detected analytes in the September 2016 sampling event, the PRGs for groundwater are shown in Table 4-9.

5. SELECTION OF REMEDIAL ALTERNATIVES

5.1 Introduction

This section summarizes the general response actions, remedial technologies, and process options as well as the criteria and methodology used to develop the soil and groundwater remedial alternatives presented in this report. The areas requiring remediation were based on the risk-based evaluation (Section 4.3) and on comparison of soil and groundwater data to the PRGs (Section 4.6). Based upon these evaluations, the landfill is the only area with exceedances requiring remediation; the Baseball Field and Shooting Range do not require remediation and are therefore not included in the remedial alternatives. A detailed discussion of the remedial alternative development process is provided in the Technical Memorandum for the Development and Screening of Remedial Alternatives (DSRA Tech Memo) dated March 2017 (Geosyntec, 2017b).

Based upon the information discussed in the RIR, Groundwater MNA Report, BHHRA, and BERA, the Site presents many of the characteristics typical of municipal landfills – it poses a low-level threat and the volume and heterogeneity of waste make treatment impracticable. Another consideration in the identification of general response actions is that 35 acres of the landfill are located within ~~an environmentally sensitive~~ a wilderness area as defined by the Wilderness Act within the GSNWR. The Site is also characterized by the presence of wetlands, FHAs, and habitat areas for endangered species (the bog turtle, Indiana bat, and blue-spotted salamander). The rural nature of this area also limits access to the Site; the existing road infrastructure, e.g. Britten Road and Green Village Road, is not designed to accommodate high volumes of heavy construction equipment. These factors were considered throughout the development of the remedial alternatives, in conjunction with other screening criteria.

5.2 Identification and Screening of Technology Types and Process Options

The general response actions, remedial technologies, and process options considered were identified from Tables 2 through 5 of the *Technical Memorandum on Candidate Technologies* (TMCT; these tables are provided in Appendix D, Arcadis, 2015) as well as in response to (i) a 20 May 2015 letter sent by USEPA regarding Comments on the TMCT and (ii) comments provided by USEPA during a project meeting in Edison, New Jersey on 14 September 2016 regarding those specific technologies.

The remedial technologies and process options identified as being potentially applicable to the Site were evaluated in two phases: preliminary screening of remedial technologies

and process options screening. Each process option was preliminarily screened with respect to the screening criteria, Site COCs, and other Site-specific factors. Preliminary screening was performed in consideration of guidance from Section 4.1.2.4 and Figure 4-4 of *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988) and previous preliminary screening results presented in Tables 2 and 3 of the TMCT.

The second phase of evaluation/screening was conducted for the process options that were retained from the preliminary screening of technologies. The evaluation/screening was based on three criteria: effectiveness, implementability, and cost. Process options were assigned ratings ranging from low to high for each category. Screening criteria for this stage of evaluation were based on guidance on the evaluation of process options presented in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988) and previous evaluation results presented in Tables 4 and 5 of the TMCT.

During the evaluation, the decision to retain a process option was based on: (1) the relative favorability of the evaluation ratings for each evaluation criterion; and, (2) the relative benefit of a process option over a similar process option. A process option may receive favorable ratings for all three criteria, but ultimately provide less effective treatment when compared to a similar process option, and therefore may not have been retained.

The following Site-specific factors strongly influenced the evaluation and screening of the identified process options:

- As discussed in Section 2.2, the evaluation and screening presented herein focuses on the assumption that there will be no residential, commercial, industrial, recreational, or any other future use on the landfill portion of the Site other than trespassing;
- Human health risks to trespassers are present in the Site soil⁴ (section 6.0);
- Minor ecological risks (hazard quotients for certain COPECs slightly greater than 1) to vermivorous birds and mammals exist in terrestrial habitat on the landfill;
- No risks for human or ecological receptors in sediment or surface water were identified in the BHHRA or BERA;

⁴ Human health risks to future adult and child residents were not considered because the future use of the Site will not include residential development.

- The areal extent of the Site is large, which, limits the feasibility of certain process options due to cost and/or implementability;
- Site access for trucks and equipment is limited to Britten Road and other Chatham Township roads, which limits the feasibility/implementability of certain process options requiring a high volume of vehicle traffic;
- The Site soil is mixed with a significant amount of municipal waste, which may make some process options ineffective and/or difficult to implement;
- Metals are present in the Site groundwater but do not appear to migrate away from the landfill likely due to differences in the geochemical conditions below and away from the landfill;
- The known non-metals groundwater impacts are localized and are believed to be limited to areas within and close to the boundaries of the landfill; and,
- The thick clay layer beneath the Site prevents vertical migration of COCs.

Process options were not evaluated in isolation; we considered the implementation of process options in conjunction with other process options. This allowed certain options to be retained, even if not applicable to all media or all COCs, provided they could be implemented in conjunction with other process options to provide an effective remedy, both for current and future Site uses. The following sections summarize the findings of the two phases of evaluation for soil and groundwater process options.

5.2.1 Soil

In the DSRA Tech Memo, 29 process options, grouped into 12 remedial technologies and then into nine general response actions, were evaluated for potential inclusion as a remedial alternative (Geosyntec, 2017b). Of these, 17 process options were not retained, as explained below.

- In-situ biological treatments bioventing and enhanced bioremediation were not retained for further consideration because they are not established technologies for treating a significant portion of the Site COCs (e.g., PCBs, metals). In addition, the effectiveness of bioventing is limited by shallow groundwater at the Site and the effectiveness of enhanced bioremediation is limited by heterogeneous media (e.g., soil mixed with varying types of waste) on Site.
- Treatment and reuse of contaminated soil was not retained for further consideration based on its technical implementability. To be reused on the Site, soil (actually a soil-waste mix) would require ex-situ treatment. None of the ex-

situ treatments were expected to be applicable to the waste-soil mixture present on the Site.

- The asphalt cap process option was not retained due to its higher cost relative to other low-permeability cap process options that offer the same effectiveness. Additionally, the asphalt cap process option would not allow for the preservation or restoration of natural habitat, further reducing its appropriateness for the Site.
- Slurry phase biological treatment was not retained because its implementation would offer little benefit over the off-Site disposal process option. Similarly, incineration was not retained because the inclusion of incineration prior to off-Site disposal would offer no increase in benefit as incineration is not applicable to inorganic COCs, the presence of which would still necessitate off-Site disposal of the incinerated soil.
- In-situ treatments oxidation/reduction and precipitations/co-precipitation were not retained because they are expected to be less effective than containment options and would still require containment to prevent direct contact. As such, in-situ oxidation/reduction and precipitation/co-precipitation offer no benefit over other containment process options.
- In-situ treatments including thermal treatment, cementation and/or solidification and/or stabilization, and soil vapor extraction and ex-situ treatment options including thermal treatment, chemical extraction, chemical reduction/oxidation, separation and solidification/stabilization were not retained because of anticipated low effectiveness and/or low implementability due to the heterogeneous nature of the soil-waste mixture present at the Site.
- Biopiles was not retained because of the long treatment time relative to other ex-situ biological treatments.
- Landfarming was not retained because it is not anticipated to be feasible for the large area and volume of soil requiring treatment, and because the soil is mixed with waste.

The remaining 12 process options, listed below, were retained for consideration during the development of remedial alternatives, as described in Section 5.3.

- No Action;
- Monitoring, i.e. inspections, of containment technologies/cover integrity;
- Institutional controls to restrict future property use;
- Access restrictions using physical barriers, signage, and security;

- Containment via a vegetative cover to prevent direct contact with contaminated material;
- Containment via a low-permeability cover to minimize infiltration and prevent direct contact with contaminated material;
- Containment via a subsurface low-permeability liner to minimize infiltration or leaching into subsurface;
- Biological in-situ treatment via phytoremediation (e.g. plants that remove, stabilize, or destroy soil constituents);
- Removal via excavation of contaminated material;
- Disposal/Discharge via off-Site disposal of material at an approved landfill;
- Disposal/Discharge via on-Site consolidation via excavation and relocation of soil on-Site with long-term management (e.g. containment); and,
- Disposal/Discharge via backfilling of excavation with clean fill.

5.2.2 Groundwater

In the DSRA Tech Memo, 29 process options for groundwater, grouped into 13 remedial technologies and then into eight general response actions, were evaluated for potential inclusion as a remedial alternative (Geosyntec, 2017b). Ten process options were not retained for further consideration as a result of the evaluation screening phase. The reasons for not retaining these process options are explained below.

- Trenched cutoff wall, sheet piling, permeable reactive wall, and passive/reactive treatment walls were not retained for further consideration because they are not effective options for mitigating on-Site impacts, only controlling off-Site migration of constituents, which is not an issue for the Site.
- Groundwater recovery trenches, chemical treatments with ozone and Fenton's Reagent/hydrogen peroxide were not retained for further consideration for the Site because they were considered less effective or offer no significant benefits over other technologies evaluated.
- Soil vapor extraction and air sparging were not retained for further consideration because they are not expected to be effective in treating the low VOC concentrations and are expected to be difficult to implement given the heterogeneous nature of the Site soil conditions.

- Advanced oxidative processes were not retained for further consideration because energy requirements, and therefore costs, of implementation are expected to be higher than comparable process options.

The remaining 19 process options, listed below, were retained for consideration during the development of remedial alternatives, as described in Section 5.3.

- No Action;
- Groundwater monitoring through the collection of groundwater samples;
- Institutional controls to restrict future groundwater use;
- MNA of impacts;
- Low-permeability cover to reduce infiltration to contaminated areas and prevent direct contact with groundwater;
- Groundwater extraction to control migration of groundwater impacts;
- Chemical in-situ treatment using persulfate for oxidation of contaminants;
- Chemical in-situ treatment using permanganate for oxidation of contaminants;
- Biological in-situ treatment via enhanced reductive dechlorination (e.g. injection of a degradable substrate to enhance biodegradation of chlorinated compounds);
- Biological in-situ treatment via aerobic bioremediation (e.g. oxygen injection into the subsurface to stimulate natural processes and precipitate metals);
- Biological in-situ treatment via phytoremediation (e.g. plants that remove, stabilize, or destroy the contaminants);
- Physical ex-situ treatment via air stripping;
- Physical ex-situ treatment via carbon adsorption;
- Chemical ex-situ treatment via ion exchange;
- Chemical ex-situ treatment via precipitation;
- Disposal/Discharge via off-Site landfill;
- Disposal/Discharge via a publicly owned treatment works under a permit;
- Disposal/Discharge via reinjection of treated groundwater; and,
- Disposal/Discharge via surface water discharge.

5.3 Identification of Remedial Alternatives

This section presents Remedial Alternatives for soil and groundwater at the Site. The Remedial Alternatives were developed from process options identified and evaluated as described in Section 5.2 and address the RAOs presented in Section 4.5.

Preliminary Remedial Alternatives were provided in the DSRA Tech Memo, compiled from the process options listed above for soil and groundwater. These remedial alternatives were developed through further evaluation of effectiveness, implementability, and estimated relative cost (Geosyntec, 2017b). Based on the results of the BHHRA and assuming institutional controls restricting future use are implemented, exposure to soil at the Site poses unacceptable risks to trespassers. The BERA identified minor ecological risks to vermivorous birds and mammals. If additional protection is provided by the selected remedial alternative, the uncertainty in the toxicity values used to calculate the risks and the observations during the 2016 BERA field investigations that the terrestrial and wetland portions of the Site are readily used by wildlife, no significant residual ecological risks are anticipated to remain following the remedial action. The groundwater remedial alternatives are designed to address the NJDEP GWQSSs, which are ARARs.

Alternatives presented in the DSRA Tech Memo were refined to account for soil conditions in certain areas of the Site that were not included in the Selected Area (Section 4.3 and Appendix B). These are defined below.

- Areas of Particular Concern (APCs) - areas where the concentration of a COC in a shallow soil sample is more than three times greater than the applicable ARS. The following soil sample locations are APCs: POI-9; POI-14; SS-90; SS-97; SS-103; SS-109; and SS-118 (Figure 5-1, Table 5-1). Sample SS-109 is adjacent to test pit TP-09. Potential industrial wastes that may be source of groundwater impacts observed in nearby monitoring well MW-3 are present at test pit TP-09. Therefore, it is anticipated that remediation of soil sample location SS-109 will also include test pit TP-09. The extents of the APCs identified above are approximate and require additional delineation in future studies.
- Mostly non-vegetated areas - areas where the existing vegetation permits access to the area and is too sparse to reduce direct contact with soil or waste and soil sample results are greater than their ARS (Figure 5-1). Mostly non-vegetated areas were identified by USEPA and the Group based on aerial photographs and during a reconnaissance at the Site on December 1, 2017. Additional data may be required to determine whether soil sample results are greater than the ARS in each of these areas.

The extent of these areas will be determined during a Pre-Design Investigation (PDI). The refinement process resulted in the final soil and groundwater alternatives developed for the Site. These alternatives are the basis of this FS report and are listed below.

5.3.1 Soil

1. No Action (as required in USEPA, 1988 and USEPA, 1991 under CERCLA as a basis for comparison with other alternatives);
2. Site Controls (i.e., Institutional Controls and Fencing and Signage)
3. Site Controls, Capping of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above the Remediation Goal;
4. Site Controls, Excavation and Off-Site Disposal of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above the Remediation Goal; and,
5. Site Controls and Capping of All Landfill Material.

Figure 5-2 depicts the soil samples containing impacts above the PRGs in relation to the approximate extent of Soil Alternatives 2 through 5.

5.3.2 Groundwater

1. No Action (as required in USEPA, 1988 and USEPA, 1991);
2. Source Control and Monitoring; and,
3. Source Control and Monitoring with a Contingent Remedy.

A description of these alternatives and a comparison of each alternative to the seven threshold and primary balancing evaluation criteria required by §300.430(e)(9)(iii) of the NCP (as discussed in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*; USEPA, 1988), is presented in Sections 6 (for soil) and 7 (for groundwater).

6. DETAILED ANALYSIS OF SOIL REMEDIAL ALTERNATIVES

This section presents the evaluation of each soil Remedial Alternative in relation to the seven threshold and primary balancing evaluation criteria required by §300.430(e)(9)(iii) of the NCP. It is aimed to identify the advantages and disadvantages of each alternative relative to one another so that the key differences can be compared. The comparative analysis includes a narrative discussion describing:

- Strengths and weaknesses relative to one another with respect to each criterion; and,
- How reasonable variation of key elements of the remedy could change their relative performance.

The purpose of the detailed analysis of remedial alternatives is to aid decision makers in selection of a Site remedy. CERCLA requires that selected remedial actions:

- Be protective of human health and the environment;
- Comply with ARARs (or provide grounds for invoking a waiver);
- Be cost-effective;
- Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and,
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element (or provide an explanation in the Record of Decision [ROD] as to why it does not).

The detailed analysis presented in this section includes:

- *Description of each remedial alternative.* The description includes remedial technologies, areas, and volumes, as applicable, and a conceptual design which is used to develop FS level remedial cost estimates (order-of-magnitude cost estimates having a desired accuracy of +50 percent to -30 percent). The cost estimates are based on currently available data and knowledge of site conditions, and therefore will be refined as more relevant information becomes available during the design phase of the selected alternative.
- *Detailed analyses of seven evaluation criteria.* As required by §300.430(e)(9)(iii) of the NCP detailed analyses were performed for the following threshold and primary balancing evaluation criteria.

- Threshold Criteria
 - (1) Overall protection of human health and the environment: The assessment describes how the alternative, as a whole, achieves and maintains protection of human health and the environment.
 - (2) Compliance with ARARs: The assessment describes how the alternative complies with ARARs or, if a waiver is required, how it is justified. The assessment also addresses other information from advisories, criteria, and guidance that the lead and support agencies have agreed are “to be considered” in evaluation of each alternative.
- Primary Balancing Criteria
 - (3) Long-term effectiveness and permanence: The assessment evaluates the long-term effectiveness of alternatives in maintaining protection of human health and the environment after response action objectives have been met.
 - (4) Reduction of toxicity, mobility, or volume through treatment: The assessment evaluates the anticipated performance of the specific treatment technologies an alternative may employ.
 - (5) Short-term effectiveness: The assessment examines the effectiveness of alternatives in protecting human health and the environment during the construction and implementation of the remedy until response action objectives have been met.
 - (6) Implementability: The assessment evaluates the technical and administrative feasibility of alternatives and the availability of required goods and services.
 - (7) Cost: The assessment evaluates the capital as well as operation and maintenance (O&M) costs of alternatives. A discount factor was not included in the estimates; however, an inflation rate for long-term monitoring was included.

In addition, the final remedy selection will also be based on evaluation of two modifying criteria: state (or support agency) acceptance; and community acceptance. The findings from the detailed analysis of the State (or support agency) acceptance and community acceptance criteria will be presented in the ROD once USEPA completes its review of, and provides comments on, the final FS Report.

The following sections describe each soil remedial alternative and include an evaluation of the alternative with respect to the threshold and primary balancing criteria. The alternatives under consideration were listed in Section 5.3.1 and include:

1. No Action (as required in USEPA, 1988 and USEPA, 1991 under CERCLA as a basis for comparison with other alternatives);
2. Site Controls (Institutional Controls, Fencing, and Signage);
3. Site Controls, Capping of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above the Remediation Goal;
4. Site Controls, Excavation and Off-Site Disposal of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above the Remediation Goal; and,
5. Site Controls and Capping of All Landfill Material.

Table 6-1 contains a summary of the comparative analysis for the soil Remedial Alternatives, which presents a relative ranking for each alternative considered with respect to each other in [USEPA's](#) the seven [NCP](#) threshold and primary balancing criteria. [The threshold criteria were also evaluated as to whether they would or would not meet the NCP criteria.](#) The ranking scale (~~4~~—for the primary balancing criteria (Excellent, followed by ~~3~~—Good, ~~2~~—Moderate, and ~~1~~—Poor) is based on anticipated positive to negative results for each criterion. For example, if minimal to no residual risk (under the detailed analysis criterion No. 3 - Long-Term Effectiveness and Permanence) is anticipated for an alternative, it is graded as “[4Excellent](#).” These grades, or rankings, are discussed as appropriate in the follow sections. [Table 6-1 also includes an estimate of the time required to reach RAOs after construction begins for each remedial alternative.](#)

The descriptions of the soil Remedial Alternatives and the cost estimates are based on the currently available data. The final extent of remediation in soil Remedial Alternatives 2 through 5 will be confirmed through a PDI and incorporated in the remedial design.

A small area at the northern end of the Surface Debris Area, approximately 4,000 square feet but not surveyed, extends onto a private residential property. As part of soil Remedial Alternatives 2 through 5, any contaminated soil will be remediated to meet New Jersey RDCSRs. The extent of remediation and the remedial approach will be determined during the PDI and remedial design, and therefore are not discussed herein. Costs for this portion of the alternative are not included because of the relatively small size of the area and because the remedial approach is not known, but costs are expected to be minor given the small size of the area to be addressed and will be the same for Alternatives 2 through 5.

6.1 Alternative 1 – No Action

This alternative provides a baseline for comparing other alternatives. No remedial activities would be implemented under this alternative, so there would be no limitations on human use of the property, and no actions to remove or isolate the COCs or waste. Exposure to the COCs at the Site would continue, so long-term human health and environmental risks for the Site will remain similar to, or the same as those identified in the baseline risk assessments.

This alternative is not protective of human health and does not alter baseline risks to the environment. Furthermore, it does not address chemical specific ARARs. As such, no evaluation of the detailed analysis criteria was performed.

6.2 Alternative 2 – Site Controls

This alternative consists of implementing Site controls (institutional controls, fencing, and signage) to limit future human use and exposure to Site COCs. Site controls reduce the long-term human health risks and ~~prevent~~minimize human exposure to contaminated soil by restricting land use and physical access. ~~The institutional controls will consist of a deed restriction and/or restrictive covenant that will preclude any further use of the Miele Trust portion~~For the portions of the Site ~~where development is not already restricted, institutional controls will preclude use of the Site~~ for any residential, commercial, industrial, recreational, or ~~any~~ other activity. ~~The institutional controls will consist of deed notices, deed restrictions, restrictive covenants and/or other land use controls that will preclude any future development of the portions of the Site where ARSs are applied.~~ The portion of the landfill on the GSNWR is already restricted from development by its designation as a Wilderness Area. ~~Recreational~~Accordingly, direct human contact related to future development of this portion of the Site is not a concern. ~~Moreover, recreational~~ use is not a reasonably anticipated use on this portion of GSNWR because of physical access restrictions due to dense vegetation and wetlands, as discussed in the BHHRA (CDM, 2014). As a result, access would be precluded and there would be no Site occupants, workers, or Site users. Therefore, the only people who might enter the Site would be trespassers. Access restrictions will include a ~~7-foot high~~ fence with signage to restrict entry to the Site by trespassers. ~~The design of the fence will be determined during the design and may vary by area of the Site to account for wildlife movement or other Site conditions.~~ The proposed location of the fence is shown in Figure 6-1. It is anticipated that the construction of the fencing will take six months to 1 year depending on the contractor's strategy/experience and Site conditions. This alternative

includes operations and maintenance activities consisting of inspections and repair of the fencing and signage to be conducted annually.

6.2.1 Overall Protection of Human Health and the Environment

- Human Health Protection: Because this alternative employs Site controls it is anticipated to improve the protection of human health as compared to no action. This alternative ~~provides moderate human health protection~~does not meet this NCP criterion.
- Environmental Protection: This alternative does not reduce ecological risk at the Site. However, the results of the BERA indicate that exposures to COPECs in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors and that there is a low potential risk for vermivorous birds and mammals. This alternative would result in limited destruction of the existing ecological habitat due to fence installation and maintenance. Overall, this alternative does not change the ecological risk from the low risk predicted under baseline conditions, ~~and it does not meet this NCP criterion.~~

6.2.2 Compliance with ARARs

- Chemical Specific ARARs: Existing concentrations of COCs in soil exceed the applicable PRGs [\(Section 4.6\)](#) established pursuant to the applicable chemical specific ARARs. This alternative does not reduce concentrations of COCs in soil and concentrations of COCs may not decrease naturally to meet the chemical specific ARARs, so ~~compliance with this alternative does not meet~~ chemical specific ARARs ~~is poor. Compliance with chemical specific ARARs is~~which are summarized in Table 6-2.
- Location Specific ARARs: This remedial alternative will be designed and implemented to comply with location specific ARARs relevant to flood hazard, wetland protection, water pollution and discharge controls, wildlife and refuge protection, and protection against introducing undesirable invasive plant species. Overall, ~~compliance with this alternative complies~~ with location specific ARARs ~~is excellent and is~~which are summarized in Table 6-2.
- Action Specific ARARs: This remedial alternative will be designed and implemented to comply with action specific ARARs relevant to air pollution/noise controls, New Jersey remediation requirements including the Technical Requirements for Site Remediation (N.J.A.C. 7:26E), occupational health and safety, investigation-derived waste management (if any), water

pollution/discharge controls, protection of ecologically sensitive natural resources (including migratory birds), and protection against introducing undesirable invasive species. Overall, this alternative complies with action specific ARARs is excellent and is which are summarized in Table 6-2.

6.2.3 Long-Term Effectiveness and Permanence

- Magnitude of Residual Risk: This alternative proposes limiting human access to manage residual risk from direct contact. It is anticipated that potential future exposure of human receptors to contaminants in soil will be reduced with these controls in place. However, this alternative does not alter the magnitude of the residual risk in the soil that is identified in the BHHRA or BERA. This alternative is ranked poor for this criterion.
- Adequacy and Reliability of Controls: Fencing/signage is a common technology to reduce potential direct contact by human receptors. Fencing/signage limits access to the Site, however trespassing by human receptors is still possible. Institutional controls such as deed ~~restriction and notices~~, deed restrictions, restrictive covenants and/or other land use controls that will preclude any future development of the portions of the Site where ARSs are applied are reliable and durable controls to minimize potential human exposure due to unauthorized land use and/or development. This alternative does not prevent ecological exposures. Overall, this alternative is ranked moderate for this criterion.

6.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

In general, as listed below, the alternative does not reduce toxicity, mobility or volume of COCs through treatment, and so it is ranked poor for this criterion.

- Treatment Process Used and Materials Treated: This alternative does not employ remedial actions to reduce or treat soil COCs.
- Amount of Hazardous Materials Destroyed or Treated: This alternative does not employ remedial actions to reduce or treat soil COCs.
- Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment: This alternative does not employ remedial actions to reduce or treat soil COCs.
- Degree to which Treatment is Irreversible: This alternative does not employ remedial actions to reduce or treat soil COCs.

- Type and Quantity of Residuals Remaining after Treatment: This alternative does not employ remedial actions to reduce or treat soil COCs.
- Whether the Alternative Would Satisfy the Statutory Preference for Treatment as a Principal Element: This alternative does not employ remedial actions to reduce or treat soil COCs and would not satisfy the statutory preference for treatment as a principal element.

6.2.5 Short-Term Effectiveness

- Protection of Community During Remedial Actions: This alternative will have minor short-term effects on the local community due to fence construction. The remedy also includes long-term monitoring which will require small teams of personnel to access the Site occasionally. This alternative is excellent for protection ~~for protection~~ of the community during remedial actions.
- Protection of Workers During Remedial Actions: This alternative will involve minimal disturbance of the Site soil due to fence construction, and the construction will be implemented in accordance with applicable Occupational Safety and Health Administration (OSHA) requirements and project-specific health and safety plan (HASP). Implementation of the health and safety requirements and plans will effectively protect workers and mitigate worker risk. This alternative is excellent in protection of workers during remedial actions.
- Environmental Impacts: This alternative will involve minimal disturbance of the Site soil and environment for installation of the access control fence. This alternative is excellent with respect to environmental impacts.
- Time Until RAOs are Achieved: This alternative is designed to prevent or minimize current and potential future unacceptable risks to current and potential future human receptors by restricting access to the Site and will be effective upon completion of construction of the fence/signage and the filing of the institutional controls. However, trespassers may still be exposed to COCs in soil through direct contact or ingestion of contaminated soil (i.e., RAO #1, as presented in Section 4.5). This alternative will not effectively prevent direct contact or ingestion of contaminated soil by ecological receptors. Therefore, RAO #1 will be only partially achieved. Overall, this alternative is considered poor with respect to the time until RAOs are achieved.

6.2.6 Implementability

This alternative uses common remedial technologies (institutional controls, fencing, and signage) that are straightforward to implement, and therefore has excellent implementability.

- Ability to Construct and Operate the Technology: This alternative proposes Site controls which are common mitigation techniques.
- Reliability of the Technology: The reliability of access restrictions (i.e., fencing/signage) increases with appropriate maintenance and care. Institutional controls (e.g., deed [notices](#), [deed restrictions](#) ~~and~~, restrictive covenants [and/or other land use controls that will preclude any future development of the portions of the Site where ARSs are applied](#)) are reliable and commonly-used controls to minimize potential human exposure due to unauthorized land use and/or development.
- Ease of Undertaking Additional Remedial Actions, If Necessary: This alternative will not significantly limit or interfere with the ability to implement or perform future remedial actions, if any.
- Ability to Monitor Effectiveness of Remedy: The effectiveness of this remedy is easily monitored through visual observation of the fence (damage, signs of trespassing, etc.) during routine inspections.
- Ability to Obtain Approvals and Coordinate with Other Agencies: This alternative will involve minimal disturbance of the soil. Therefore, the ability to obtain approvals of the proposed technology and coordinate with other agencies is anticipated to be excellent.
- Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity: This alternative does not involve off-Site treatment, storage, and disposal.
- Availability of Necessary Equipment and Specialists: Site controls (institutional controls, fencing, and signage) are common technologies. It is anticipated that the ability to obtain the necessary materials and personnel to implement them is excellent.
- Availability of Prospective Technology: Site controls (institutional controls, fencing, and signage) are common. No difficulties are anticipated in obtaining the necessary materials for this remedial alternative.

6.2.7 Cost

The detailed cost estimate of this alternative is provided in Table 6-3, and the summary of the cost estimate is below:

- Indirect Capital Cost (Design/Construction Oversight/Permits): \$63,400
- Direct Capital Costs: \$515,400
- Post-Construction Operation, Maintenance, and Monitoring Costs: \$182,200
- Total Costs: \$761,000

Assumptions, notes, and limitations considered during the development of the cost estimate for the alternatives are provided in Table 6-4.

6.3 Alternative 3 – Site Controls, Capping of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above the Remediation Goals

Alternative 3 consists of implementation of Alternative 2 (Site ~~controls~~ Controls) together with remediation of the Selected Area (described in Section 4.3) by capping. Alternative 3 addresses COCs in surface soil which contribute the majority of the risk to trespassers (adult and adolescent) in the Current and Reasonably Anticipated Future Use Scenario in the BHHRA. In addition, this alternative includes remediation of the APCs and mostly non-vegetated areas (as described in Section 5.3). These areas are presented in Figure 6-2.

Site controls are described above in Remedial Alternative 2 (Section 6.2) and will address any COCs remaining after remedy construction. Capping of the Selected Area (approximately 25 acres), remediation of the APCs (approximately 7 acres), and remediation of the mostly non-vegetated areas (approximately 2 acres), along with Site controls would significantly reduce potential exposure to contaminated soil for humans and ecological receptors and achieve the RAOs. ~~Remediation of each APC~~ In each case, the area of test pit TP-09 will be excavated to the water table, and the excavated material will be disposed of off-Site because the material in this specific area is a potential source of contaminants to groundwater. Remediation of each APC, except for TP-09 as discussed above, will be conducted using one of the following options, which will be selected based on the results of the PDI:

- Alternative 3a – excavation of contaminated soil (to a maximum 2 feet bgs, which equates to approximately 22,600 cubic yards [cyd]), backfilling, and consolidating the excavated soil under the cap of the Selected Area;

- Alternative 3b – installing a cap over each APC; or
- Alternative 3c – excavation of contaminated soil (to a maximum 2 feet bgs, which equates to approximately 22,600 cyd_±* if all APCs are excavated), backfilling, and off-Site disposal of the excavated soil.

[The volume requiring remediation will be determined based on the PDI results.](#)

Accordingly, Alternative 3 is described as including three variations:

- Alternative 3a – Site Controls, Capping of Selected Area to Reduce Overall Risk, Remediation (Consolidation Under Selected Area Cap) of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals
- Alternative 3b – Site Controls, Capping of Selected Area to Reduce Overall Risk, and Remediation (Cap In-Place) of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals
- Alternative 3c – Site Controls, Capping of Selected Area to Reduce Overall Risk, Remediation (Off-Site Disposal) of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals

Final implementation of Alternative 3 is likely to include a combination of remedial approaches from Alternatives 3a, 3b, and 3c to address the individual APCs, as determined by the results of the PDI. Alternative 3 includes operations and maintenance activities to be conducted annually, including inspections and repair of the fence and caps.

Assumptions and cost breakdowns for this alternative, as well as the potential cap components, are provided in Tables 6-4, 6-5, 6-6a, 6-6b, and 6-6c; key assumptions include:

- General Assumptions Applicable to the Selected Area, APCs, and Mostly Non-Vegetated Areas
 - Cut trees generated from clearing and grubbing prior to the cap construction or contaminated soil excavation will be either chipped and placed under the cap, disposed of off-Site, or processed for reuse (e.g., mulch).

- Existing dense vegetation, as discussed in the BHHRA (CDM, 2014), which is present across most of the Site, will deter access and therefore minimizes risks from direct soil contact.
- During construction, surface water and sediment may be monitored to verify these media are not adversely impacted by the remediation activities.
- The capped or backfilled areas will be re-vegetated using a seed mix of species native to New Jersey. For areas on the GSNWR, to the extent practicable and consistent with engineering best practices, restoration will align with the 2014 GSNWR Comprehensive Conservation Plan (CCP) and will be conducted in consultation with USFWS.
- Additional Assumptions for the Selected Area
 - In the Selected Area, a protective cap will be used; the potential cap components are presented in Table 6-5.
- Additional Assumptions for the APCs
 - Alternative 3a Additional Assumptions
 - The material excavated from the APCs under Alternative 3a will be consolidated under the cap of the 25-acre Selected Area and the APCs will be backfilled with clean fill.
 - Alternative 3b Additional Assumptions
 - APCs will be capped using a protective cap; the potential cap components are presented in Table 6-5.
 - To the extent this variation is used for APCs located in the flood hazard area (including APCs POI-9, POI-14, SS-109, and SS-118, totaling approximately 4 acres), these APCs will be excavated to 3 feet bgs (equating to approximately 19,400~~300~~ cyd) prior to capping so that the construction of the protective cap (approximately 3-feet thick) does not reduce the flood storage capacity in the flood hazard area as a result of its construction.
 - Alternative 3c Additional Assumptions
 - The material excavated from the APCs under Alternative 3c will be disposed of off-Site.
- Assumptions for the Mostly Non-Vegetated Areas

- The mostly non-vegetated areas which contain COCs above the PRGs outside the APCs and the Selected Area will be remediated to minimize risk associated with potential direct human contact with soil in these areas.
- Remediation of the mostly non-vegetated areas will consist of either scarifying and seeding the soil surface soil or adding up to 1.5 feet of topsoil cover and seeding it. The seed mix used in the mostly non-vegetated areas could include deep-rooted plants since there is no need to prevent the roots from growing through the soil and into the underlying waste.

Capping and excavation/backfilling can be performed with standard construction equipment⁵, but will require thousands of truck trips (estimated at between 22,500~~800~~ and 26,700~~27,300~~ over a two- to three-year period for this remedial alternative) to haul materials several miles through residential areas on narrow streets not built for heavy truck traffic, and large truck traffic over soft soil conditions at the Site. Each load of soil or fill brought into or removed from the Site requires one round trip, which equates to two truck trips through Chatham Township⁶. For example, to bring a load of clean soil, a full truck drives to the Site, is unloaded, and then drives away from the Site. The number of truck trips was estimated as follows:

⁵ The use of standard construction equipment within the GSNWR is limited by the designation of this area as a Wilderness Area.

⁶ The potential reuse of on-Site soil as clean backfill, which would reduce the number of truck trips through Chatham Township, can be investigated during the PDI.

Component	Alternative		
	3a	3b	3c
Access Road	750	750	750
	(8,300 cyd material @ 22 cyd/truck)		
Cap	17,500	22,400	17,500
	(192,500 tons material for Alternatives 3a/c and 246,500 tons material for Alternative 3b @ 22 tons/truck)		
Mostly Non-Vegetated Areas	720	720	720
	(7,850 tons materials @ 22 tons/truck)		
Off-Site Disposal	4300	4300	2,100
	(3,300 tons @ 22 tons/truck for Alternatives 3a and 3b; 22,600 tons @ 22 tons/truck for Alternative 3c)		
Backfill	2,100	4300	2,100
	(3,300 cyd @ 22 cyd/truck for Alternative 3b; 22,600 cyd material @ 22 cyd/truck for Alternatives 3a/c)		
Wetland Reconstruction	1,100	2,500	1,100
	(11,800 tons material for Alternatives 3a/c and 27,500 tons material for Alternative 3b @ 22 tons/truck)		
Fence	260	260	260
	(6,500 feet of fence @ 50-feet fence materials/truck)		
Total Truck Trips	~22,500 800	~26,700 27,300	~24,500

The capped and excavated/backfilled areas will be revegetated with species native to New Jersey. For areas on the GSNWR, to the extent practicable and consistent with engineering best practices, restoration will align with the 2014 GSNWR CCP and will be conducted in consultation with USFWS.

6.3.1 Overall Protection of Human Health and the Environment

- Human Health Protection:** This alternative employs a cap covering contaminated soil in the Selected Area and remediation (i.e., consolidation and capping, capping in place, or excavation and off-Site disposal of contaminated soil) of the APCs along with Site controls (i.e., fence, signage, and institutional controls) that will significantly reduce the potential for physical contact with contaminated soil. Remediation technologies in this alternative reduce human exposure risk by either creating a physical barrier from the contaminated soil or by excavating and disposing of the contaminated material off-Site, and by restricting access and future use. This alternative also employs vegetative cover that will be used for the mostly non-vegetated areas shown on Figure 6-2 to reduce direct exposure to

soil at the Site. Therefore, it is anticipated that this alternative will significantly reduce the human health risk by reducing the potential for the direct exposure of human receptors using physical barriers (i.e., capping), removal of contaminated soil, and Site controls. Overall, Alternative 3 will ~~provide excellent~~ meet the NCP criterion for protection of human health.

- Environmental Protection: The results of the BERA indicate that exposures to COPECs in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors and that there is a low potential risk for vermivorous birds and mammals. Implementation of this alternative would reduce ecological risks posed by COPECs by up to 59% (Appendix C). Though some of the calculated post-remedy risks were slightly above a risk quotient threshold of 1, most of the risks are at or near those found in reference areas and/or within the bounds of the uncertainty in the risk calculations. These findings, coupled with the presence of a varied ecological community similar to that found in similar habitats in New Jersey, results in high confidence that that any potential residual ecological risk following remedy implementation is negligible. The existing ecological habitats within the 25-acre Selected Area, which includes old field habitat, mature tree stands, and peripheral wetlands, would be eliminated and be replaced with maintained grassy areas which have lower ecological value than the existing vegetated habitats. In addition, small areas of potential habitat for the federally threatened and State endangered bog turtle ([Figure 6-2](#)) and blue-spotted salamander, ([Integral, 2016, BERA Figure D4-1 and Figure 6-2](#)), as well as mature trees that are potential roosting habitat for the federally threatened and State endangered Indiana bat, ([Geosyntec, 2018, RIR, Attachment C, Appendix B](#)), would be lost permanently. Capped and excavated/backfilled areas will be revegetated with species native to New Jersey. For areas on the GSNWR, to the extent practicable and consistent with engineering best practices, restoration will align with the 2014 GSNWR CCP and will be conducted in consultation with USFWS. Overall, this alternative ~~is judged to provide goodwill~~ meet the NCP criterion for environmental protection.

6.3.2 Compliance with ARARs

As discussed below, Alternative 3 provides excellent compliance with ARARs.

- Chemical Specific ARARs: Existing concentrations of COCs in soil exceed the applicable PRGs ([Section 4.6](#)) pursuant to their applicable chemical specific ARARs. This remedial alternative will mitigate exposure by Site controls

(institutional controls, fencing, and signage), capping and/or removal of contaminated soil from the Selected Area and APCs, and soil placement and vegetation of the mostly non-vegetated areas. ~~Although contaminant concentrations are not necessarily reduced, this~~ This alternative complies with all meets the NCP criterion for chemical specific ARARs by reducing potential for current and future exposure to COCs, surface COC concentrations. Compliance with each chemical specific ARARs is detailed in Table 6-2.

- Location Specific ARARs: This remedial alternative will be designed and implemented to comply with location specific ARARs relevant to the flood hazard area, wetland protection, water pollution/discharge controls, wildlife and refuge protection, and protection against introducing undesirable invasive plant species. This alternative meets the NCP criterion for location specific ARARs. Compliance with location specific ARARs is summarized in Table 6-2.
- Action Specific ARARs: This remedial alternative will be designed and implemented to comply with action specific ARARs relevant to landfill standards, air pollution/noise controls, New Jersey remediation requirements including the Technical Requirements for Site Remediation (N.J.A.C. 7:26E), occupational health and safety, investigation-derived waste management (if any), water pollution/discharge controls, hazardous waste management standards (if excavated soil to be disposed of off Site is determined to be hazardous waste), protection of ecologically sensitive natural resources (including migratory bird), and protection against introducing undesirable invasive species. This alternative meets the NCP criterion for action specific ARARs. Compliance with action specific ARARs is summarized in Table 6-2.

6.3.3 Long-Term Effectiveness and Permanence

As discussed below, Alternative 3 provides excellent long-term effectiveness and permanence.

- Magnitude of Residual Risk: Capping contaminated soil of the Selected Area and APCs will significantly reduce the potential for direct exposure and minimize contaminant mobility (i.e., the potential for the spread of soil contamination) and residual risks. Excavation and consolidation or off-Site disposal of contaminated soil in the APCs is anticipated to significantly reduce residual risk by eliminating or minimizing the potential for direct exposure and spread of contamination. Vegetative cover placed in non-vegetated areas will reduce direct contact with soil for both human and ecological receptors. Site controls will further mitigate

risk to humans by limiting on-Site use and access and reducing the likelihood for direct exposure. Overall, this alternative provides excellent reduction in the magnitude of residual risk.

- *Adequacy and Reliability of Controls*: Capping is a robust and reliable technology widely used for remediation and landfill closures to prevent direct exposure and reduce contaminant mobility. This alternative also employs Site controls (institutional controls, fencing, and signage) that are widely used, adequate, and reliable for preventing unauthorized human access on-Site. With proper maintenance in combination with the Site controls, the reliability of the cap will increase. Excavation and off-Site disposal is also a widely used and reliable technology for remediation of contaminated soil.

6.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

In general, Alternative 3 does not include treatment. However, the remedial measures will lead to some reduction in toxicity, mobility, or volume, as discussed below.

- *Treatment Process used and Materials Treated*: This alternative does not employ remedial actions to treat soil COCs.
- *Amount of Hazardous Materials Destroyed or Treated*: This alternative does not employ remedial actions to treat soil COCs.
- *Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment*: Capping the Selected Area will reduce mobility and excavation and off-Site disposal will reduce volume and toxicity. The contaminated soil in the APCs will be remediated through one or more of the following options: 1) excavated and consolidated under the Selected Area cap, which will reduce mobility, toxicity, and volume of COCs in areas outside the Selected Area, 2) capped, which will reduce mobility, and/or 3) excavated and then disposed of off-Site, which will reduce volume and toxicity of the COCs. As a result, Alternative 3 is ranked excellent for this criterion.
- *Degree to which Treatment is Irreversible*: This alternative does not employ remedial actions to treat soil COCs.
- *Type and Quantity of Residuals Remaining after Treatment*: This alternative does not employ remedial actions to treat soil COCs, only to isolate or remove them.
- *Whether the Alternative Would Satisfy the Statutory Preference for Treatment as a Principal Element*: This alternative does not employ remedial actions to treat soil COCs and would not satisfy the statutory preference for treatment as a principal element.

6.3.5 Short-Term Effectiveness

- Protection of Community During Remedial Actions:* This alternative will involve controlled disturbance of existing habitats and contaminated soil during construction of the cap and contaminated soil excavation and backfilling, and minimal or negligible disturbance of soil during installation of Site access controls. Moderate short-term effects on the local community will occur during the construction of the remedy components because of an increase in traffic due to construction material, personnel, equipment, and soil transportation to and from the Site. As provided in Section 6.3, the estimated number of truck trips (one round trip counts as two truck trips) to implement this remedial alternative is ~~22,500 to 26,700 over two to three years~~ 800 to 27,300 over two to three years. Using on site material for backfill or capping to potentially reduce truck traffic will be evaluated during the remedial design To the extent remedial construction causes damage to Britten Road, efforts will be undertaken to restore the road to the condition it was in prior to the start of construction. The remedy also includes long-term monitoring which will require small teams of personnel to access the Site occasionally. Overall, this alternative provides good protection of the community during remedial actions.
- Protection of Workers During Remedial Actions:* This alternative will involve controlled disturbance of contaminated soil and construction of the fence and caps, and excavation of contaminated soil. The construction will be implemented in accordance with applicable OSHA requirements and project-specific HASP. Implementation of the health and safety requirements and plans will effectively protect workers and mitigate worker risk. Overall, this alternative provides excellent protection of workers during remedial actions.
- Environmental Impacts:* This alternative will involve controlled disturbance of the existing habitat and contaminated soil during excavation, capping and fencing. The remedial design of this alternative will take into account protection of the environment and wildlife habitats (such as potential bog turtle habitats) by incorporating Best Management Practices (BMPs) and coordinating with USFWS as needed. This Including access and staging footprints, this alternative involves ~~destruction of~~ destroying approximately 3 to 7 acres of wetlands, and mitigation of destroyed wetlands will be implemented. The actual area and value of wetlands to be destroyed and appropriate mitigation methods will be determined during the PDI and remedial design. Capped and excavated/backfilled areas will be revegetated with species native to New Jersey. For areas on the GSNWR, to the

extent practicable and consistent with engineering best practices, restoration will align with the 2014 GSNWR CCP and will be conducted in consultation with USFWS. Environmental impacts during post-construction care activities (e.g., operation, maintenance, and monitoring of the cap) will be minimal although access roads on the landfill will need to be maintained. Overall, this alternative will provide good protection against environmental impacts.

- *Time Until RAOs are Achieved:* The Site controls, capping system, and off-Site disposal of contaminated soil will achieve the applicable RAOs relevant to contaminated soil (RAO #1) upon completion of construction. It is anticipated the remedial action construction will take two to three years. This alternative is rated excellent.

6.3.6 Implementability

As discussed below, Alternative 3 provides excellent implementability for all criteria.

- *Ability to Construct and Operate the Technology:* This alternative includes installing a cap over contaminated soil in the Selected Area and potentially at the APCs, constructing Site access controls (i.e., fence), and potential soil excavation/backfilling at the APCs, all of which are common technologies and readily implementable. There are construction challenges associated with the presence of wetlands and high-value wildlife habitats adjacent to the remediation areas and minimizing habitat and wetland destruction when incorporating stormwater controls for the Selected Area cap. Construction truck traffic along Britten Road and Green Village Road as well as truck movement on soft, swampy soils pose additional construction challenges. This alternative does not include a treatment technology and thus post-construction operation will be limited to maintenance and monitoring of the cap, vegetative cover, and fence.
- *Reliability of the Technology:* A cap is a reliable physical barrier that prevents direct exposure and mitigates residual risks. The reliability of a cap increases with appropriate maintenance and care. Excavation and consolidation and/or off-Site disposal is also a widely accepted and reliable technology for remediation of contaminated soil. Fencing and signage are widely used as a physical barrier to mitigate direct exposure. The reliability and effectiveness of fencing and signage increases with appropriate maintenance and care.
- *Ease of Undertaking Additional Remedial Actions, If Necessary:* Future remedial measures would not be anticipated in this alternative; however, if they were to be implemented they would likely consist of minor repairs to the Site controls (fence

or signage) or cap. Overall this alternative will not limit the ability to implement or perform these potential future remedial actions, if any. However, the additional remedial actions may require temporary or permanent removal of the cap. While the removal and repair of a cap is a relatively common practice and can be implemented with common construction equipment, it could be challenging depending on the location or extent of the removal and repair.

- *Ability to Monitor Effectiveness of Remedy:* This alternative employs physical barriers (cap, vegetative cover, and fence). In addition, Alternatives 3a and 3c employ excavation and either consolidation or off-Site disposal of impacted soils, respectively, from the APCs. The effectiveness of the physical barriers can be assessed through visual inspections to determine the condition of the barriers, i.e. whether they are damaged, or whether other factors are affecting their physical condition. The effectiveness of the excavation of the APCs is easily monitored, as well.
- *Ability to Obtain Approvals and Coordinate with Other Agencies:* This alternative will involve controlled disturbance of soil and wetlands and construction of a protective cap (Table 6-5). No significant difficulties are anticipated in obtaining approvals of the proposed technologies coordinating with other agencies.
- *Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity:* This alternative does not involve off-Site treatment, storage, and disposal with the exception of potential disposal of contaminated soil from the APCs. If off-Site disposal is selected for remediation of the APCs, it is anticipated that the ability to dispose of the contaminated soil at an off-Site disposal facility will be excellent because the volume is relatively small compared to Alternative 4.
- *Availability of Necessary Equipment and Specialists:* Caps, Site controls, and excavation/consolidation/off-Site disposal are common technologies. No significant difficulties are anticipated in obtaining the necessary equipment and personnel to construct and implement these remedial actions.
- *Availability of Prospective Technology:* Caps, Site controls, and excavation/off-Site disposal are common technologies. No significant difficulties are anticipated in obtaining the necessary materials for this remedial alternative.

6.3.7 Cost

The detailed cost estimate of this alternative is provided in Tables 6-6a, 6-6b, and 6-6c, and the summary of the cost estimate is below:

	Alternative 3a	Alternative 3b	Alternative 3c
Indirect Capital Costs	\$1,771,800902,000	\$2,016,600073,900	\$2,507,400
Direct Capital Costs	\$11,709,70012,563,500	\$13,314,600690,300	\$16,532,900
Post-Construction OMM Costs	\$2,058,600	\$2,058,600	\$2,058,600
Total Costs ⁽⁴⁾	\$15,54116,525,000	\$17,390823,000	\$21,099,000

Notes

- (1) Alternative 3a – Site Controls, Capping of Selected Area to Reduce Overall Risk, Remediation (Consolidation Under Selected Area Cap) of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals
- (2) Alternative 3b – Site Controls, Capping of Selected Area to Reduce Overall Risk, and Remediation (Cap In-Place) of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals
- (3) Alternative 3c – Site Controls, Capping of Selected Area to Reduce Overall Risk, Remediation (Off-Site Disposal) of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals
- (4) Total costs are rounded up to the thousands place. The cost estimates assume the same technology will be applied to each APC; however, it is possible that not all APCs will be remediated with the same listed technology (e.g., some may be capped, others excavated and disposed of off-Site).

Assumptions, notes, and limitations considered during the development of the cost estimate for the alternatives are provided in Table 6-4.

6.4 Alternative 4 – Site Controls, Excavation and Off-Site Disposal of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above the Remediation Goals

Alternative 4 is similar to Alternative 3; however, the 25-acre Selected Area will be excavated and disposed of off-Site, and the excavated area will be backfilled (Figure 6-2). It is assumed the contaminated soil in the Selected Area will be excavated to a depth of 2 to 4 feet bgs (equating to approximately 80,700 cyd to 161,400 cyd, respectively). Thus, the elements of Alternative 4 are:

- Site controls (institutional controls, fence, and signage);

- Excavation and off-Site disposal of contaminated soil from the Selected Area, followed by backfilling the excavation;
- Remediation of the APCs; and,
- Remediation of non-vegetated areas with soil sample results above remediation goals.

Remediation for the APCs includes either:

For the APC in the area of test pit TP-09, that APC will be excavated to the water table, and the excavated material will be disposed of off-Site because the material in this specific area is a potential source of contaminants to groundwater. Remediation for the other APCs includes either:

- Alternative 4a – installing a cap over each of the APCs; or
- Alternative 4b – excavation of contaminated soil (to a maximum 2 ft bgs, which equates to approximately 22,600 cyd if all APCs are excavated), followed by off-Site disposal of the excavated soil and then backfilling the excavations.

Accordingly, Alternative 4 is described as having two variations:

- Alternative 4a - Site Controls, Excavation and Off-Site Disposal of Selected Area to Reduce Overall Risk, Remediation (Cap In-Place) of Areas of Particular Concern, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals
- Alternative 4b - Site Controls, Excavation and Off-Site Disposal of Selected Area to Reduce Overall Risk, Remediation (Off-Site Disposal) of Areas of Particular Concern, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals

Final implementation of Alternative 4 will likely include a combination of remedial approaches from Alternatives 4a and 4b to address the APCs, depending on the results of the PDI. This alternative includes operations and maintenance activities to be conducted annually, including inspections and repair of the fence and caps (if any).

Assumptions for this alternative are provided in Tables 6-4, 6-5, 6-7a, and 6-7b; key assumptions include:

- General Assumptions Applicable to the Selected Area, APCs, and Mostly Non-Vegetated Areas

- Cut trees generated from clearing and grubbing prior to the cap construction or contaminated soil excavation would be either chipped and placed under the cap on the APCs (under Alternative 4a), disposed of off-Site, or processed for reuse (e.g., mulch).
 - Existing dense vegetation, as discussed in the BHHRA (CDM, 2014), which is present across most of the Site, will deter access and therefore minimizes risks from direct soil contact.
 - During construction, surface water and sediment may be monitored to verify these media are not adversely impacted by the remediation activities.
 - The capped or backfilled areas will be re-vegetated using a seed mix of species native to New Jersey. For areas on the GSNWR, to the extent practicable and consistent with engineering best practices, restoration will align with the 2014 GSNWR CCP and will be conducted in consultation with USFWS.
-
- Additional Assumptions for the Selected Area
 - The depth of the excavation of the Selected Area has been estimated to be between 2 and 4 feet bgs. The actual depth will be determined during the remedial design.
 - After excavation and off-Site disposal, the Selected Area will be backfilled with clean fill and topsoil to the original grades and then re-vegetated.
 - Additional Assumptions for the APCs
 - Alternative 4a Additional Assumptions
 - Under Alternative 4a, APCs will be capped using a protective cap; the potential cap components are presented in Table 6-5.
 - For capping APCs located in the flood hazard area under Alternative 4a (including APCs POI-9, POI-14, SS-109, and SS-118, totaling approximately 4 acres), it is assumed the APC areas will be excavated to 3 feet bgs (equating to approximately 19,400 ~~300~~ cyd) prior to capping so that the construction of the protective cap (approximately 3-feet thick) does not reduce the flood storage capacity in the flood hazard area as a result of its construction.
 - Alternative 4b Additional Assumptions

- After excavation and off-Site disposal, the APCs will be backfilled with clean fill and topsoil to the original grades and then re-vegetated.
- Additional Assumptions for the Mostly Non-Vegetated Areas
 - The mostly non-vegetated areas which contain COCs above the PRGs outside the APCs and the Selected Area will be remediated to minimize risk associated with potential direct human contact with soil in these areas.
 - Remediation of the mostly non-vegetated areas will consist of either scarifying and seeding the soil surface soil or adding up to 1.5 feet of topsoil cover and seeding it. The seed mix used in the mostly non-vegetated areas could include deep-rooted plants since there is no need to prevent the roots from growing through the soil and into the underlying waste.

Capping, excavation and backfilling can be performed with standard construction equipment⁷, and will require thousands of truck trips to haul materials several miles through residential areas on narrow streets not built for heavy truck traffic (estimated at 22,000 to ~~37,500~~38,100 truck trips over two to four years), large truck traffic over soft soil conditions, the need to characterize all the material being transported off Site (e.g., hazardous and/or non-hazardous) and identifying an appropriate disposal facility that can accept the large volume of material to be removed from the Site. Each load of soil or fill brought into or removed from the Site requires one round trip, which equates to two truck trips through Chatham Township⁸. For example, to bring a load of clean soil, a full truck drives to the Site, is unloaded, and then drives away from the Site. The number of truck trips was estimated as follows:

⁷ The use of standard construction equipment within the GSNWR is limited by the designation of this area as a Wilderness Area.

⁸ The potential reuse of on-Site soil as clean backfill, which would reduce the number of truck trips through Chatham Township, can be investigated during the PDI.

Component	Alternative	
	4a	4b
Access Road	750 (8,300 cyd material @ 22 cyd/truck)	750
Cap	4,900 (53,900 tons material for Alternative 4a @ 22 tons/truck)	0
Mostly Non-Vegetated Areas	720 (7,850 tons material @ 22 tons/truck)	720
Off-Site Disposal	7,300 - 14,700 15,000* (808,000-164,700-161,400 tons for Alternative 4a and 103,300-184,000 tons for Alternative 4b @ 22 tons/truck)	9,400 - 16,700*
Backfill	7,300 - 14,700 15,000* (same volume/truck loads to replace off-Site disposal material)	9,400 - 16,700*
Wetland Reconstruction	1,450 (15,700 tons material @ 22 tons/truck)	1,450
Fence	260 (6,500 feet of fence @ 50-feet fence materials/truck)	260
Total Truck Trips	~23,000 - 37,500 ~38,100*	~22,000 - ~36,600*

Note:

* - The range of values are for the 2 ft and 4 ft excavation options in the Selected Area, respectively.

6.4.1 Overall Protection of Human Health and the Environment

- Human Health Protection:** This alternative employs removal of contaminated soil in the Selected Area and remediation (i.e., capping in place or excavation and off-Site disposal of contaminated soil) of the APCs along with Site controls (i.e., fence, signage, and institutional controls) that will reduce the potential for physical contact with contaminated soil. Remediation technologies in this alternative reduce human exposure by either creating a physical barrier from, or excavating and disposing off-Site, the contaminated soil and by restricting access and future use. This alternative also employs vegetative cover that will be used for the mostly non-vegetated areas shown on Figure 6-2 to reduce direct exposure to soil at the Site. Therefore, it is anticipated that this alternative will significantly reduce the human health risk by reducing the potential for the direct exposure of human receptors using soil removal (and possibly capping, if Alternative 4a is

selected) and Site controls. Overall, this alternative ~~would provide excellent~~ [meets the NCP criterion for](#) human health protection.

- Environmental Protection: The results of the BERA indicate that exposures to COPECs in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors and that there is a low potential risk for vermivorous birds and mammals. Implementation of this alternative would reduce ecological risks posed by COPECs by up to 59% (Appendix C). Though some of the calculated post remedy risks were slightly above a risk quotient threshold of 1, most of the risks are at or near those found in reference areas and/or within the bounds of the uncertainty in the risk calculations. These findings, coupled with the presence of a varied ecological community similar to that found in similar habitats in New Jersey, results in high confidence that that any potential residual ecological risk following remedy implementation is negligible. The existing ecological habitats within the 25-acre Selected Area, which includes old field habitat, mature tree stands, and peripheral wetlands, would be eliminated and be replaced with maintained grassy areas which have lower ecological value than the existing vegetated habitats. In addition, small areas of potential habitat for the federally threatened and State endangered bog turtle and blue-spotted salamander, as well as mature trees that are potential roosting habitat for the federally threatened and State endangered Indiana bat, would be lost permanently. Capped and excavated/backfilled areas will be revegetated with species native to New Jersey. For areas on GSNWR, to the extent practicable and consistent with engineering best practices, restoration will align with the 2014 GSNWR CCP and will be conducted in consultation with USFWS. Overall, this alternative ~~would provide good~~ [meets the NCP criterion for](#) environmental protection.

6.4.2 Compliance with ARARs

As discussed below, Alternative 4 provides excellent compliance with ARARs.

- Chemical Specific ARARs: Existing concentrations of COCs in soil exceed the applicable PRGs ([Section 4.6](#)) pursuant to the applicable chemical specific ARARs. This remedial alternative will be designed and implemented to comply with chemical specific ARARs relevant to the regulatory remediation standards by Site controls, physical controls (i.e., removal of contaminated soil from the Selected Area, capping and/or removal of contaminated soil from the APCs, and soil placement and vegetation of the mostly non-vegetated area). This alternative complies with all chemical specific ARARs by [reducing surface COC](#)

concentrations through a combination of removal and off-Site disposal ~~and reducing potential~~. This alternative meets the NCP criterion for current and future exposure to COCs—chemical specific ARARs. Compliance with chemical specific ARARs is detailed in Table 6-2.

- Location Specific ARARs: This remedial alternative will be designed and implemented to comply with location specific ARARs relevant to the flood hazard area, wetland protection, water pollution/discharge controls, wildlife and refuge protection, and protection against introducing undesirable invasive plant species. This alternative meets the NCP criterion for location specific ARARs. Compliance with location specific ARARs is summarized in Table 6-2.
- Action Specific ARARs: This remedial alternative will be designed and implemented to comply with action specific ARARs relevant to landfill standards (if the APCs are to be capped), air pollution/noise controls, New Jersey remediation requirements including the Technical Requirements for Site Remediation (N.J.A.C. 7:26E), occupational health and safety, investigation-derived waste management (if any), water pollution/ discharge controls, hazardous waste management standards (if excavated soil to be disposed of off Site is determined to be hazardous waste), protection of ecologically sensitive natural resources (including migratory bird), and protection against introducing undesirable invasive species. The alternative meets the NCP for action specific ARARs. Compliance with action specific ARARs is summarized in Table 6-2.

6.4.3 Long-Term Effectiveness and Permanence

As discussed below, Alternative 4 provides excellent long-term effectiveness and permanence.

- Magnitude of Residual Risk: Excavation and off-Site disposal of contaminated soil in the Selected Area and APCs is anticipated to significantly reduce residual risk by eliminating or minimizing the potential for direct exposure and spread of contamination. Capping contaminated soil in the APCs, if selected, is anticipated to significantly reduce the potential for direct exposure and minimize contaminant mobility (i.e., the potential for the spread of soil contamination). Vegetative cover placed in mostly non-vegetated areas will reduce potential exposure to COCs in soil. Site controls will further mitigate human health risk by posing limitations on Site use and access, reducing the likelihood for direct exposure. Overall, this alternative provides excellent reduction in the magnitude of residual risk.

- *Adequacy and Reliability of Controls*: Excavation and off-Site disposal is a widely used, adequate, and reliable technology for remediation of contaminated soil. Capping is also an adequate and reliable technology widely used for remediation and landfill closures to prevent direct exposure and reduce contaminant mobility and residual risks. This alternative also employs Site controls that are widely used for remediation, construction, and other purposes. Site controls are effective in preventing unauthorized human access and Site use and therefore adequate and reliable. The potential for trespassing is reduced by Site controls with proper maintenance. Proper maintenance in combination with the Site controls increases the reliability of the cap.

6.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

In general, Alternative 4 does not include treatment. However, the remedial measures will lead to some reduction in toxicity, mobility, or volume, as discussed below.

- *Treatment Process used and Materials Treated*: This alternative does not employ remedial actions to treat soil COCs.
- *Amount of Hazardous Materials Destroyed or Treated*: This alternative does not employ remedial actions to treat soil COCs.
- *Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment*: This alternative does not employ remedial actions to treat soil COCs in situ. However, the Selected Area will be excavated and disposed off-Site, which will reduce the volume and toxicity of the COCs. The contaminated soil in the APCs will be either capped, which will reduce mobility, or excavated and then disposed of off-Site, which will reduce volume and toxicity of the COCs. Therefore, the toxicity, mobility and volume of the soil COCs will be significantly reduced. As a result, Alternative 4 is ranked excellent for this criterion.
- *Degree to which Treatment is Irreversible*: This alternative does not employ remedial actions to treat soil COCs.
- *Type and Quantity of Residuals Remaining after Treatment*: This alternative does not employ remedial actions to treat soil COCs.
- *Whether the Alternative Would Satisfy the Statutory Preference for Treatment as a Principal Element*: This alternative does not employ remedial actions to treat soil COCs and would not satisfy the statutory preference for treatment as a principal element.

6.4.5 Short-Term Effectiveness

- Protection of Community During Remedial Actions:* This alternative will involve controlled disturbance of existing habitat and contaminated soil during excavation of contaminated soil, and construction of the cap (Alternative 4a), and minimal or negligible disturbance of soil during installation of Site controls. Moderate short-term effects on the local community will occur during the construction of the remedy components because of an increase in traffic due to construction material, personnel, equipment, and soil transportation to and from the Site. As presented in Section 6.4, the estimated number of truck trips to implement this remedial alternative is 22,000 to ~~37,500 over two to four years.~~ 38,100 over two to four years. Using on site material for backfill or capping to potentially reduce truck traffic will be evaluated during the remedial design. To the extent remedial construction causes damage to Britten Road, efforts will be undertaken to restore the road to the condition it was in prior to the start of construction. The remedy also includes long-term monitoring which will require small teams of personnel to access the Site occasionally. Overall, this alternative provides moderate protection of the community during remedial actions.
- Protection of Workers During Remedial Actions:* This alternative will involve controlled disturbance of contaminated soil and construction of the fence and caps, if selected. The extent of the excavation in this alternative is greater than in Alternative 3 (potentially much greater if the excavation in the Selected Area extends to 4 feet bgs), and excavation of the landfill may be difficult because the landfill contents are heterogenous, excavation walls may not be stable, and the landfill may not provide reliable working surfaces for the earth moving equipment. Therefore, the risks to workers are greater. The construction will be implemented in accordance with applicable OSHA requirements and project-specific HASP. Implementation of the health and safety requirements and plans will be relied on to protect workers and mitigate worker risk. Overall, this alternative provides moderate protection of workers during remedial actions.
- Environmental Impacts:* This alternative will involve controlled disturbance of ecological habitat and contaminated soil during contaminated soil excavation and construction of the fence and caps, if selected. The remedial design of this alternative will account for protection of the environment and high-value wildlife habitats (such as potential bog turtle habitats) by incorporating BMPs and coordinating with USFWS as needed. This Including access and staging footprints, this alternative involves ~~destruction of~~ destroying approximately 4 to 8

acres of wetlands, and mitigation of destroyed wetlands will be implemented. [The actual area and value of wetlands to be destroyed and appropriate mitigation methods will be determined during the PDI and remedial design.](#) Capped and excavated/backfilled areas will be revegetated with species native to New Jersey. For areas on the GSNWR, to the extent practicable and consistent with engineering best practices, restoration will align with the 2014 GSNWR CCP and will be conducted in consultation with USFWS. Environmental impacts during post-construction care activities (e.g., operation, maintenance, and monitoring of the cap) will be minimal although access roads on the landfill would need to be maintained. Overall, this alternative will provide good protection against environmental impacts.

- *Time Until RAOs are Achieved:* The Site controls, cap, and off-Site disposal of contaminated soil will achieve the RAOs relevant to contaminated soil (RAO #1) upon completion of the remedial construction. It is anticipated the remedial action construction will take two to four years. Overall, Alternative 4 is rated good with respect to time to achieve RAOs.

6.4.6 Implementability

As discussed below, Alternative 4 provides [generally provides good to](#) excellent implementability for most criteria. The exceptions are noted below.

- *Ability to Construct and Operate the Technology:* This alternative includes soil excavation with backfilling, a vegetative cover in the mostly non-vegetated areas, potentially installing a cap over contaminated soil in APCs, and constructing Site controls (i.e., fence). All of these are common technologies and readily implementable. There are construction challenges associated with the presence of wetlands and high-value wildlife habitats adjacent to the remediation areas and minimizing habitat and wetland destruction when incorporating stormwater controls for the Selected Area cap. Also, if the excavation [in the Selected Area](#) extends to 4 feet bgs, the excavation side walls in the landfilled material may become unstable, requiring benching, shoring, or other means to prevent collapse, leading to significant additional costs. The truck traffic along Britten Road and Green Village Road, as well as truck movement on soft, swampy soils pose additional construction challenges. This alternative does not include a treatment technology and thus post-construction operation will be limited to maintenance and monitoring of the cap (if constructed), vegetative cover, and fence. The ability to construct and operate this alternative is good.

- Reliability of the Technology: Excavation and off-Site disposal is a widely accepted, reliable technology for remediation of contaminated soil. A cap is also a reliable physical barrier that prevents direct exposure and mitigates residual risks. Reliability of a cap increases with appropriate maintenance and care. Access restrictions are widely used as a physical barrier to mitigate direct exposure. The reliability of access restrictions (i.e., fencing) increases with appropriate maintenance and care. With proper maintenance, access restrictions are effective in limiting trespassing. This alternative is ranked excellent.
- Ease of Undertaking Additional Remedial Actions, If Necessary: Overall this alternative will not limit the ability to implement or perform future additional remedial actions, if any. However, additional remedial actions may require temporary or permanent removal of the cap in the APCs, if Alternative 4a is selected. While the removal and repair of a cap is a common practice and can be implemented with common construction equipment, it could be challenging depending on the location or extent of the removal and repair. Therefore, this alternative is ranked good for this criterion.
- Ability to Monitor Effectiveness of Remedy: The effectiveness of the physical barriers (vegetative cover, fence, and cap on APCs if Alternative 4a is implemented) can be assessed based on the condition of the barriers, whether they are damaged, or whether other factors are affecting their physical condition. Therefore, this alternative is ranked good for this criterion.
- Ability to Obtain Approvals and Coordinate with Other Agencies: This alternative will involve controlled disturbance of soil and wetlands and construction of a protective cap (if Alternative 4a is implemented), which is a commonly-used cap for closing solid waste landfills. No significant difficulties are anticipated in obtaining approvals of the proposed technologies and in coordinating with other agencies. Therefore, this alternative is ranked good for this criterion.
- Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity: This alternative does not involve off-Site treatment and storage. It is anticipated that the ability to dispose of the contaminated soil from the Selected Area (and APCs, if Alternative 4b is selected) at an off-Site disposal facility will be moderate. This rating is lower than in Alternative 3 because the amount of material being removed from the Site and disposed of off-Site in Alternative 4 is greater than in Alternative 3 and may lead to difficulties in securing landfill space.
- Availability of Necessary Equipment and Specialists: Excavation with off-Site disposal, caps, and Site controls, are common technologies. No significant

difficulties are anticipated in obtaining the necessary equipment and personnel. Therefore, this alternative is ranked excellent for this criterion.

- Availability of Prospective Technology: Excavation with off-Site disposal, caps, Site controls are common technologies. No significant difficulties are anticipated in obtaining the necessary technologies to construct and implement this alternative. Therefore, this alternative is ranked excellent for this criterion.

6.4.7 Cost

The detailed cost estimate of this alternative is provided in Tables 6-7a and 6-7b, and the summary of the cost estimate is below. A range of costs is provided to reflect the potential range in the depth of excavation in the Selected Area (at least 2 feet bgs, and potentially as much as 4 feet bgs).

	Alternative 4a	Alternative 4b
Indirect Capital Costs	\$2,486,700 - \$4,411,200 519,800 444,000	\$2,771,600 - \$4,696,300
Direct Capital Costs	\$27,880,100 - \$49,388,400 28,251,800 760,300	\$31,065,000 - \$52,573,400
Post-Construction OMM Costs	\$2,058,600	\$522,000
Total Costs ⁽³⁾	\$32,426,831,000 - \$55,859,56,264,000	\$34,359,000 - \$57,792,000

Notes

- (1) Alternative 4a - Site Controls, Excavation and Off-Site Disposal of Selected Area to Reduce Overall Risk, Remediation (Cap In-Place) of Areas of Particular Concern, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals
- (2) Alternative 4b - Site Controls, Excavation and Off-Site Disposal of Selected Area to Reduce Overall Risk, Remediation (Off-Site Disposal) of Areas of Particular Concern, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals
- (3) Total costs are rounded up to the thousands place. The cost estimates assume the same technology will be applied to each APC; however, it is possible that not all APCs will be remediated with the same listed technology (e.g., some may be capped, others excavated and disposed of off-Site).

Assumptions, notes, and limitations considered during the development of the cost estimate for the alternatives are provided in Table 6-4.

6.5 Alternative 5 – Site Controls and Capping of All Landfill Material

Alternative 5 includes construction of a protective cap over the entire landfill (140 acres), excavation of contaminated soil from the APCs that are outside the landfill, and Site controls. These features are illustrated on Figure 6-3. The potential cap components are presented in Table 6-5. [The impact of this alternative on flooding will be considered during design.](#) The APCs POI-9 and POI-14 are not located on the landfill, and therefore would be excavated (to a maximum depth of 2 feet bgs, which equates to approximately 6,500 cyd) and consolidated under the cap. [In addition, the APC at the location of TP-09, will be excavated to the water table and the material disposed of off-Site, because the material in this specific area is a potential source of contaminants to groundwater.](#) Site controls are described in Section 6.2 and will address any COCs remaining after remedy construction. This alternative includes operations and maintenance activities to be conducted annually, including inspections and repair of the fence and cap.

Capping and excavation/backfilling can be performed with standard construction equipment⁹. Implementability of this scenario is limited by the need to haul a significant amount of material (i.e., significantly more material than in Soil Alternatives 3 and 4; see Tables 6-6(a,b,c) and 6-7(a,b) for the estimated material quantities for each alternative) to the Site, requiring an estimated 106,000 truck trips several miles through residential areas over a three to four year period. Each load of soil or fill brought into or removed from the Site requires one round trip, which equates to two truck trips through Chatham Township¹⁰. For example, to bring a load of clean soil, a full truck drives to the Site, is unloaded, and then drives away from the Site. The number of truck trips was estimated as follows:

Component	Alternative 5
Access Road	750 (8,300 cyd material @ 22 cyd/truck)
Cap	98,000 (1,078,000 tons material @ 22 tons/truck)
Off-Site Disposal	300 (3,300 cyd material @ 22 cyd/truck)

⁹ The use of standard construction equipment within the GSNWR is limited by the designation of this area as a Wilderness Area.

¹⁰ The potential reuse of on-Site soil as clean backfill, which would reduce the number of truck trips through Chatham Township, can be investigated during the PDI.

Component	Alternative 5
Backfill	590,890 (6,500 9,800 cyd material @ 22 cyd/truck)
Wetland Reconstruction	6,500 (71,400 tons material @ 22 tons/truck)
Fence	260 (6,500 feet of fence @ 50-feet fence materials/truck)
Total Truck Trips	~106,000

During construction, surface water and sediment may be monitored to verify these media are not adversely impacted by the remediation activities. To the extent practicable and consistent with engineering best practices, capped and excavated/backfilled areas will be revegetated with species native to New Jersey. For areas on GSNWR, to the extent practicable and consistent with engineering best practices, restoration will align with the 2014 GSNWR CCP and will be conducted in consultation with USFWS. The woody habitat loss and impact on wetlands are proportional to the size of the area capped, and therefore are much greater for Soil Alternative 5 than for Soil Alternatives 3 or 4.

6.5.1 Overall Protection of Human Health and the Environment

- Human Health Protection: This alternative employs capping of the entire landfill, removal of contaminated soil from APCs outside the landfill footprint, and Site controls using a fence with signage and institutional controls (e.g., Site Use restrictions), which will significantly reduce the potential for direct human exposure to contaminated soil and thus provide excellent human health protection. Overall, this alternative meets the NCP criterion for human health protection.
- Environmental Protection: The results of the BERA indicate that exposures to COPECs in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors and that there is a low potential risk for vermivorous birds and mammals. Implementation of this alternative would reduce ecological risks posed by COPECs by up to 99% (Appendix C). As was the case for the other alternatives, some of the calculated post remedy risks were slightly above a risk quotient threshold of 1, but most of the risks are at or near those found in reference areas and/or within the bounds of the uncertainty in the risk calculations. Under this alternative, however, the existing ecological habitats of the landfill surface, such as the old field habitat, mature tree stands, and wetlands (18 acres) would be eliminated and replaced with maintained grassy areas, which

have lower ecological value than the existing habitats outside of the exposed fill areas. In addition, some small areas of potential habitat for the federally threatened and State endangered bog turtle and blue-spotted salamander, as well as mature trees that are potential roosting habitat for the federally threatened and State endangered Indiana bat would be lost permanently from their current location, though wetlands could be replaced at another location at the Site or off-Site. Overall, given habitat and species disturbances, the overall net ecological benefit of implementing Alternative 5 is less than Alternatives 3 and 4. Capped and excavated/backfilled areas will be revegetated with species native to New Jersey. For areas on the GSNWR, to the extent practicable and consistent with engineering best practices, restoration will align with the 2014 GSNWR CCP and will be conducted in consultation with USFWS. Overall, this alternative ~~will provide moderate~~[meets the NCP criterion for](#) environmental protection.

6.5.2 Compliance with ARARs

As discussed below, Alternative 5 provides excellent compliance with ARARs.

- *Chemical Specific ARARs:* Existing concentrations of COCs in soil exceed the applicable PRGs ([Section 4.6](#)) pursuant to the applicable chemical specific ARARs. This remedial alternative will be designed and implemented to comply with Chemical Specific ARARs relevant to the regulatory remediation standards by Site controls, physical controls (i.e., capping the entire landfill and removing contaminated soil from the APCs outside of the landfill footprint). This alternative complies with all chemical specific ARARs by [reducing surface COC concentrations by](#) a combination of removal and off-Site disposal and reducing potential for current and future exposure ~~to COCs~~. [This alternative complies with this NCP criterion](#). Compliance with chemical specific ARARs is summarized in Table 6-2.
- *Location Specific ARARs:* This remedial alternative will be designed and implemented to comply with location specific ARARs relevant to the flood hazard area, wetland protection, water pollution/discharge controls, wildlife and refuge protection, and protection against introducing undesirable invasive plant species. [This alternative complies with this NCP criterion](#). Compliance with location specific ARARs is summarized in Table 6-2.
- *Action Specific ARARs:* This remedial alternative will be designed and implemented to comply with action specific ARARs relevant to landfill standards, air pollution/noise controls, New Jersey remediation requirements including the

Technical Requirements for Site Remediation (N.J.A.C. 7:26E), occupational health and safety, investigation-derived waste management (if any), water pollution/discharge controls, protection of ecologically sensitive natural resources (including migratory bird), and protection against introducing undesirable invasive species. Action specific ARARs relevant to hazardous waste management are not applicable to this alternative as no waste will be disposed of at an off-Site facility. [This alternative complies with this NCP criterion.](#) Compliance with action specific ARARs is summarized in Table 6-2.

6.5.3 Long-Term Effectiveness and Permanence

As discussed below, Alternative 5 provides excellent long-term effectiveness and permanence.

- *Magnitude of Residual Risk:* Capping the entire landfill (and thus contaminated soil) and removal of contaminated soil from the APCs outside of the landfill are anticipated to significantly reduce the potential for direct exposure and minimize contaminant mobility (i.e., the potential for the spread of soil contamination). Site controls will further mitigate residual risk to humans by posing limitations on Site access, use, and reducing the likelihood for direct exposure. Overall, this alternative provides excellent reduction in the magnitude of residual risk.
- *Adequacy and Reliability of Controls:* Capping is an adequate and reliable technology widely used for remediation and landfill closures to prevent direct exposure and reduce contaminant mobility and residual risks. Excavation and consolidation of contaminated soil under the landfill cap is also a widely used, adequate, and reliable technology for contaminated soil remediation. This alternative also employs Site controls that are widely used for remediation, construction, and other purposes. Site controls are effective in preventing unauthorized human access on Site and are therefore adequate and reliable with proper maintenance. With proper maintenance in combination with the Site controls, the reliability of the cap will increase. Overall, the adequacy and reliability of the controls in Alternative 5 are excellent.

6.5.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

In general, Alternative 5 does not include treatment. However, the remedial measures will lead to some reduction in mobility and will reduce the volume and toxicity of soil that is outside the capped area, as discussed below.

- Treatment Process Used and Materials Treated: This alternative does not employ remedial actions to treat soil COCs.
- Amount of Hazardous Materials Destroyed or Treated: This alternative does not employ remedial actions to treat soil COCs.
- Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment: This alternative does not employ remedial actions to treat soil COCs. However, the landfill will be capped, and the soil in the APCs outside the landfill will be excavated and consolidated under the cap. Therefore, the mobility of the COCs will be reduced within the capped area. The toxicity and volume of the soil COCs will be significantly reduced outside the capped area. As a result, Alternative 5 is ranked excellent for this criterion.
- Degree to which Treatment is Irreversible: This alternative does not employ remedial actions to treat soil COCs.
- Type and Quantity of Residuals Remaining after Treatment: This alternative does not employ remedial actions to treat soil COCs.
- Whether the Alternative Would Satisfy the Statutory Preference for Treatment as a Principal Element: This alternative does not employ remedial actions to treat soil COCs and would not satisfy the statutory preference for treatment as a principal element.

6.5.5 Short-Term Effectiveness

- Protection of Community During Remedial Actions: This alternative will involve controlled disturbance of contaminated soil during excavation in the APCs, construction of the cap, and implementation of Site controls. Soil disturbance associated with the cap construction activities (e.g., tree clearing and grubbing, ground grading and shaping, cap anchor trench, etc.) are anticipated to occur. Cut trees would be either chipped and placed under the cap, disposed of off-Site, or processed for reuse (e.g., mulch). No hauling of contaminated soil from the Site is included in this alternative. However, significant short-term effects on the local community will occur during the construction of the remedy components including construction traffic to haul material and equipment to and from the Site for the 140-acre cap. As provided in Section 6.5, the estimated number of truck trips to implement this remedial alternative is 106,000 over three to four years. 600 over three to four years. Using on site material for backfill or capping to potentially reduce truck traffic would be evaluated during the remedial design. To the extent remedial construction causes damage to Britten Road, efforts will be

[undertaken to restore the road to the condition it was in prior to the start of construction.](#) The remedy also includes long-term monitoring which will require small teams of personnel to access the Site occasionally. Overall, this alternative provides poor protection of the community during remedial actions.

- ***Protection of Workers During Remedial Actions:*** This alternative will involve controlled disturbance of contaminated soil during construction of the fence and cap and contaminated soil excavation in the APCs. The construction will be implemented in accordance with applicable OSHA requirements and project-specific HASP. Implementation of the health and safety requirements and plans will effectively protect workers and mitigate worker risk. However, given the size of the project and the remote, inaccessible locations where some of the work will take place, this alternative may present more challenging safety issues compared to other alternatives. Overall, this alternative provides good protection of workers during remedial actions.
- ***Environmental Impacts:*** This alternative will involve destruction of ecological habitat and controlled disturbance of contaminated soil during construction of the fence and cap as a result of tree clearing and grubbing, ground grading and shaping, anchor trench construction, and other tasks. To the extent practicable, the remedial design of this alternative will take account of protection of the environment and high-value wildlife habitats outside the landfill area (such as those associated with potential bog turtle habitats) by incorporating BMPs and coordinating with USFWS as needed. However, this alternative involves capping 140 acres and ~~destruction of~~[destroying](#) approximately 18 acres of wetlands [\(including access and staging areas\)](#), more than the approximately 3 to 8 acres of wetlands destroyed under Alternatives 3 and 4~~5~~, and therefore a high degree of short-term environmental impact is anticipated. [The impact of this alternative on potential flooding will be considered during design.](#) For costing purposes, it is assumed that wetlands destroyed by capping will be reconstructed on-Site because it will be challenging to replicate the same value of wetlands off-Site. However, it is possible that off-Site replication will be necessary because of limited space for on-Site wetland reconstruction after capping the entire landfill (140 acres). [The actual area and value of wetlands to be destroyed and appropriate mitigation methods will be determined during the PDI and remedial design.](#) Capped and excavated/backfilled areas will be revegetated with species native to New Jersey. For areas on the GSNWR, to the extent practicable and consistent with engineering best practices, restoration will align with the 2014 GSNWR CCP and will be conducted in consultation with USFWS. Environmental impacts during

post-construction care activities (e.g., operation, maintenance, and monitoring of the cap) will be minimal. Overall, because of the extensive changes to the existing habitat, this alternative will provide poor protection against short-term environmental impacts.

- *Time Until Remedial Action Objectives are Achieved:* The Site controls, contaminated soil excavation, and cap will achieve the RAOs relevant to contaminated soil (RAO #1) upon completion of remedial construction. Remedial construction is expected to take three to four years to complete. Because its construction duration is longer than the other alternatives, Alternative 5 is rated moderate in time to achieve RAOs.

6.5.6 Implementability

As discussed below, the implementability of Alternative 5 varies depending on the specific criteria.

- *Ability to Construct and Operate the Technology:* This alternative includes constructing fence and signage, removal of contaminated soil, and installing a cap, which are common technologies and readily implementable. However, this alternative involves capping the entire 140-acre landfill, which includes and is adjacent to wetlands and open water. Construction of a cap of this size will require substantial grading and earth movement to ensure that grades are adequate for runoff and slope stability, and that runoff is adequately managed so it does not adversely impact the surrounding wetlands. Due to limited space on-Site, the replication of destroyed wetlands may be implemented off-Site (for costing purposes on-Site reconstruction was assumed). In addition, there are some construction challenges associated with 1) the presence of high-value wildlife habitats (which may cause significant delay in construction), 2) compensating flood storage capacity loss due to the cap, and 3) incorporating stormwater controls into the limited Site space (construction of stormwater basins may not be feasible on the capped landfill). The truck traffic along Britten Road and Green Village Road as well as truck movement on soft, swampy soils pose additional construction challenges (for example, truck traffic through residential and commercial areas may be restricted during certain times to prevent impacts to other travelers). This alternative does not include a treatment technology and thus post-construction operation will be limited to maintenance and monitoring of the cap and fence. The ability to construct and operate this alternative is moderate.

- Reliability of the Technology: A cap is a reliable physical barrier that prevents direct exposure and mitigates residual risks. Reliability of a cap increases with appropriate maintenance and care. Excavation and consolidation of contaminated soil under the landfill cap is also a commonly accepted reliable technology for soil remediation. Access restrictions are widely used as a physical barrier to mitigate direct exposure. The reliability of access restrictions increases with appropriate maintenance and care. With proper maintenance, access restrictions are effective in limiting trespassing. The reliability of this technology is considered excellent.
- Ease of Undertaking Additional Remedial Actions, If Necessary: As this alternative proposes to construct a cap over the 140-acre entire landfill, it is anticipated that additional remedial actions, if necessary, will be challenging to implement. Additional remedial actions may require temporary or permanent removal of a portion of, or the entire, cap. While the removal and repair of a cap is a common practice and can be implemented with common construction equipment, it could be challenging depending on the location or extent of the removal and repair. As such, any additional remedial action may result in rebuilding the cap (entire or partial). As a result, the ease of undertaking additional remedial actions in Alternative 5 is considered moderate.
- Ability to Monitor Effectiveness of Remedy: This alternative employs physical barriers (cap of the entire landfill and fence) and soil removal (excavation and consolidation of contaminated soils excavated from the APCs outside of the landfill footprint). The effectiveness of the physical barriers can be assessed based on the condition of the barriers, whether they are damaged, or whether other factors are affecting their physical condition. The ability to monitor the effectiveness of Alternative 5 is considered excellent.
- Ability to Obtain Approvals and Coordinate with Other Agencies: While a cap is commonly used for closing solid waste landfills, this alternative will involve significant disturbance and destruction of wetlands, grading and shaping to compensate the flood storage capacity loss due to the cap, and capping the entire 140-acre landfill. In addition, coordination with the USFWS will be required to construct the cap within the GSNWR. It is anticipated that the ability to obtain approval to implement Alternative 5 and to coordinate with other agencies will be moderate.
- Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity: This alternative does not involve off-Site treatment, storage, or disposal, so Alternative 5 will have excellent compliance with this criterion.

- Availability of Necessary Equipment and Specialists: Caps, soil excavation, and Site controls (i.e., fence) are common technologies. It is anticipated that the ability to obtain the necessary equipment and personnel is excellent.
- Availability of Prospective Technology: Caps, soil excavation, and Site controls (i.e., fence) are common technologies. It is anticipated that the ability to obtain the necessary materials to construct and implement them is excellent.

6.5.7 Cost

The detailed cost estimate of this alternative is provided in Table 6-8, and the summary of the cost estimate is below:

- Indirect Capital Cost (Design/Construction Oversight/Permits): ~~\$4,572,300~~ \$4,677,900
- Direct Capital Costs: ~~\$46,192~~ \$46,256,200
- Post-Construction Operation, Maintenance, and Monitoring Costs: \$3,495,900
- Total Costs: ~~\$54,264~~ \$55,430,000

Assumptions, notes, and limitations considered during the development of the cost estimate for the alternatives are provided in Table 6-4. Note that it is assumed that the 18 acres of wetlands destroyed during implementation of this alternative can be reconstructed on-Site. However, if that is not the case, then wetland replication would have to take place off-Site, and the cost would increase approximately \$9,000,000 based on current wetland credit values.

6.6 Comparative Analysis of Alternatives

The purpose of the comparative analysis is to identify and compare the pros and cons of the soil remedial action alternatives relative to each other using the information contained in the detailed analysis of alternatives. This comparison is organized around the seven threshold and balancing criteria described in Section 6.0. Table 6-1 contains a summary of the comparative analysis for the soil remedial action alternatives, which presents a relative ranking for each alternative considered with respect to each other in USEPA's the seven NCP threshold and primary balancing criteria.

~~The following table summarizes the scores for the five soil alternatives, based on the scores in Table 6-1. As the scores are relative, not absolute, and all the criteria are weighted equally in the total score, the total score is not a definitive evaluation of the remedial alternative. Judgment must still be used in comparing the remedial alternatives and a reviewer may decide to weigh certain criteria more than others. However, the total~~

scores do provide an overall indication of how well each alternative meets the USEPA's seven threshold and primary balancing criteria.

Remedial Alternative	Total Score
Alternative 1—No Action	NA
Alternative 2—Site Controls (i.e., Institutional Controls and Access Restrictions)	78
Alternative 3—Site Controls, Capping of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals	91 (3a) 91 (3b) 90 (3c)
Alternative 4—Site Controls, Excavation and Off Site Disposal of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals	80 (4a) 80 (4b)
Alternative 5—Site Controls and Capping of All Landfill Material	71

6.6.1 Overall Protection of Human Health and the Environment

The BHHRA presumed that no remedial actions are taken to address environmental impacts. The BHHRA evaluated human exposure scenarios, and results indicate that for no action (i.e., Alternative 1) (i) estimated cancer risks and non-cancer health hazards to the majority of potential receptors in the Current and Reasonably Anticipated Future Exposure Scenario (BHHRA Scenario 1) are within or less than USEPA target levels, (ii) estimated non-cancer hazard to one BHHRA Scenario 1 receptor is slightly greater than the USEPA target level, but HIs for individual target organs are all less than or equal to the USEPA target level of 1, and (iii) estimated non-cancer health hazard to two BHHRA Scenario 1 receptors (adolescent and adult trespassers) is greater than the USEPA target level.

The results of the BERA indicate that, for no action, exposures to COPECs in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors, and that there is a low potential risk for vermivorous birds and mammals.

For purposes of comparing the various alternatives, Alternative 1 (No Action) is not considered applicable. Because Alternatives 2 through 5 involve remedial actions, including Site controls (institutional controls, fence, and signage), capping, and/or excavation and consolidation or off-Site disposal of contaminated soil, additional layers of protection of human health and the environment would be provided above the No Action alternative. In comparing Alternatives 2 through 5, Alternative 2 is anticipated to reduce direct exposure to the COCs in soil at the Site to trespassers, but because it does not include all the remedial elements in Alternatives 3 through 5, it is not considered as protective of human health and the environment. Alternative 5 has the most extensive remedial activities because the remedial actions (capping and consolidation) will be implemented throughout the entire landfill and the APCs that are outside the landfill. Although the areas to be remediated in Alternatives 3 and 4 are smaller than in Alternative 5, [the each alternative is protective of human health. The remedial actions in Alternatives 3 and 4 \(remediation of the Selected Area and the APCs, and placing a clean soil layer with vegetation over the mostly non-vegetated areas\), address the areas with the highest concentrations of COCs, so the risk reduction is similar to Alternative 5. Alternatives 3, 4, and 5 all result in HQs which are protective of ecological receptors, but Alternative 5 does result in lower HQs for some COCs.](#) However, Alternative 5 involves destroying all the established mature trees and woody habitat, old field habitat, and wetlands on the 140-acre landfill and replacing it with maintained grassy areas, which have lower ecological value than the existing habitats. In addition, some small areas of potential habitat for the federally threatened and State endangered bog turtle and mature trees that are potential roosting habitat for the federally threatened and State endangered Indiana bat would be lost permanently from their current location, though wetlands could be [enhanced](#), reconstructed or replicated at another location at the Site or off-Site. Alternatives 2, 3, and 4 impact existing habitat and wetlands but to a much lesser degree than Alternative 5. Overall, Alternatives 3 and 4 are rated equivalently high for protection of human health and the environment. Alternative 5 is equivalent to Alternatives 3 and 4 in human health protection but is ranked lower than Alternatives 3 and 4 in environmental protection because of the extent of habitat destruction. Alternative 2 is ranked lowest in both human health and environmental protection (Table 6-1).

6.6.2 Compliance with ARARs

Alternative 2 will not meet the chemical specific ARARs (and thus the PRGs). The remedial actions included in Alternatives 3 through 5 will meet the chemical specific ARARs [by reducing surface concentrations of COCs](#) through a combination of Site controls, capping, and/or excavation and off-Site disposal. All of the remedial

alternatives will be designed and implemented to comply with the action specific and location specific ARARs, and therefore compliance with ARARs of Alternatives 3 through 5 is equivalently high. [Specifically, compensating for flood storage capacity loss due to the cap and incorporating stormwater controls into the limited Site space will be design challenges for Alternative 5.](#) However, compliance with the Wilderness Act and other ARARs applicable to the GSNWR will create additional challenges and add costs to the portions of the landfill that are on the GSNWR. Additional challenges include compliance with the GSNWR rules which might impact access, use of equipment, building of roads or other physical access, or other limitations that would not apply to work on the Miele portion of the Site. Overall, Alternatives 3 through 5 are ranked excellent whereas Alternative 2 is considered poor for compliance with ARARs because it will not meet chemical specific ARARs.

6.6.3 Long-Term Effectiveness and Permanence

Alternative 2 will involve Site controls (institutional controls, fence, and signage). This alternative does not reduce the residual risk in the soil at the Site, and provides less protection than Alternatives 3, 4, and 5. The long-term effectiveness and permanence of Alternative 2 is expected to be moderate to poor. Like Alternative 2, Alternatives 3 through 5 include Site controls, and also include more robust and permanent components (capping and/or excavation of contaminated soil). With proper management and care of Site controls and caps, it is anticipated that the long-term effectiveness and permanence of Alternatives 3 through 5 are excellent.

6.6.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The soil remedial alternatives do not include treatment of the COCs and therefore do not satisfy the preference for treatment as a principal element of the remedial action. Thus, they are rated poor in all categories except the “degree of expected reductions in toxicity, mobility or volume through treatment” category. In that category, Alternatives 3 through 5 all include capping and/or excavation (and then consolidation under the cap or disposal off-Site) of contaminated soil, and therefore reduce the mobility (when capping) and the volume and toxicity (when excavating) of COCs in soil. Although the areas to be remediated in Alternatives 3 and 4 are smaller than in Alternative 5, the remedial actions (capping and/or removal of contaminated soil) in Alternatives 3 and 4 address soil in the areas with the highest concentrations of COCs and therefore the reduction in the toxicity, mobility, or volume of COCs is similar to Alternative 5. As such, the degree of the

expected reduction of toxicity, mobility, and/or volume of the soil COCs for Alternatives 3 through 5, are all evaluated to be excellent.

6.6.5 Short-Term Effectiveness

Construction of Alternative 5 will result in the highest traffic increase and the longest construction duration compared to Alternatives 2, 3, and 4, and therefore provides the least protection of the community. In addition, because it involves clearing, grading, and capping the entire landfill, Alternative 5 has the greatest short-term impact on the habitat at the Site. Alternative 2 causes the least traffic increase and has the shortest construction duration but does not meet RAOs and therefore cannot be considered effective in the short term. Alternatives 3 and 4 both have construction traffic, although three to five times less than Alternative 5. More risk is anticipated during Alternative 4 than Alternative 3 since Alternative 4 would involve a greater volume of excavation and transportation of contaminated soil to an off-Site disposal facility than Alternative 3. In addition, if the excavation of the Selected Area in Alternative 4 extends to 4 feet bgs, the excavation sidewalls may become unstable and pose an additional risk to workers. Overall, Alternative 3 is the most effective in the short-term, followed by Alternatives 4, 5, and 2.

6.6.6 Implementability

In comparison of Alternatives 2 through 5, Alternative 2 involves the fewest construction components and the least habitat disturbance. Alternative 3 has more remedial components than Alternative 2, but the scope and complexity of those components are typical of remediation projects so Alternative 3 is considered equivalent to Alternative 2 in implementability. The scopes of Alternatives 3 and 4 are similar, but Alternative 4 would involve excavation, transportation, and off-Site disposal of more contaminated soil and waste than Alternative 3, and thus the ability to construct and operate Alternative 4 is evaluated to be lower than for Alternative 3. If Alternative 4 extends to an excavation of 4 feet bgs, issues such as the need for benching or shoring will decrease the implementability of Alternative 4 as compared to Alternative 3. The size of the remedial construction area, significant wetland destruction, and limited space for stormwater basins in Alternative 5 make implementation much more difficult than Alternatives 2, 3, and 4. Overall, the implementability of Alternatives 2 and 3 are equivalently excellent, followed by Alternative 4 and then Alternative 5.

6.6.7 Cost

Table 6-9 presents the summary of the remedial construction cost estimates for the soil Remedial Alternatives. There is no cost to implement Alternative 1 because no remedial action will be implemented. Alternative 5 will likely be more costly than any other alternative as it is the biggest area to be remediated (capped) and will involve the greatest impacts to the environment and wetlands (the costs estimated for Alternative 5 assume that wetland will be restored on-Site, but if they must be replicated off-Site, the total cost of this alternative will be approximately \$9,000,000 higher based on current wetland credit values). While the same footprint areas will be remediated under Alternatives 3 and 4, Alternative 4 is more costly than Alternative 3 because off-Site disposal of contaminated soil from the Selected Area is more expensive than capping; in fact, if the excavation of the Selected Area in Alternative 4 extends to 4 feet bgs, the estimated cost of Alternative 4 is essentially equivalent to the cost of Alternative 5. Alternative 2 is the least expensive alternative.

6.6.8 Summary

Alternatives 3 and 4 are evaluated to be reliable and effective alternatives that meet the threshold criteria (protection of human health and the environment and compliance with ARARs) by removing or capping the contaminated soil and placing soil over and vegetating the mostly non-vegetated areas. Alternative 5 is equivalent to Alternatives 3 and 4 in protection of human health and compliance with ARARs, but is less effective in protection of the environment. Alternative 2 is not protective of human health or the environment, is not anticipated to meet the Chemical Specific ARARs, and is not considered reliable or effective.

Alternative 2 is expected to require 6 months to one year to implement, the most rapid of the alternatives; however, it will not meet ARARs and therefore is not considered effective in the short or long term. For Alternatives 3 and 4, the estimated timeframes to attain RAOs are similar (2 to 3 years, although Alternative 4 could take longer if the excavation of the Selected Area extends to 4 feet bgs). Alternative 5 will require 3 to 4 years, depending on the contractor's approach and experience, permitting, and Site conditions. Alternative 3 is considered the most effective in the short term because it meets RAOs, has less impact on the community, presents less risks to workers, and can be implemented more quickly than Alternatives 4 or 5.

Implementability of Alternatives 2 through 5 varies based on the amount and location of capping and/or excavation and off-Site disposal. Alternative 2 includes Site controls, but

no excavation/backfilling or capping. Alternative 3 has more remedial components than Alternative 2, but the components are readily implementable so Alternatives 2 and 3 are both ranked equivalently high in implementability. Alternatives 3 and 4 are similar in scope and effectiveness, but Alternative 4 includes excavation/backfilling and off-Site disposal for the Selected Area (as opposed to capping of this area in Alternative 3). Off-Site disposal of contaminated soil (Alternative 4) may impose some challenges in finding a proper disposal facility and transportation. Therefore, Alternative 4 is less implementable than Alternatives 2 and 3 and will become even less implementable as the depth of excavation increases.

The scope of Alternative 5 (capping the entire 140-acre landfill and excavating APCs outside the landfill) is much greater than any other alternative. Capping the large area under Alternative 5 will impose challenges in undertaking additional remedial actions, if necessary, and obtaining approvals and coordinating with other agencies. Alternatives 3 through 5 are anticipated to significantly increase traffic in Chatham and on Green Village and Britten Roads during remedial action implementation, with Alternative 5 having the greatest impact on traffic, surrounding residents, and businesses, followed by Alternative 4 and then Alternative 3.

Alternative 5 is likely the most costly remedial alternative. This is due largely to the amount of clean fill to be brought into the Site to create the 140-acre cap for Alternative 5. The cost for Alternative 4, which includes off-Site disposal of soil and waste from the Selected Area, is the next highest and if the excavation of the Selected Area extends to 4 feet bgs, is essentially the same cost as Alternative 5. The cost for Alternative 3 is less than Alternative 4, although the extent of remediation, overall protectiveness, and compliance with ARARs in each of these alternatives is the same. Alternative 2 has the lowest cost.

7. DETAILED ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVES

7.1 Introduction

This section presents the evaluation of each remedial alternative for groundwater in relation to the seven threshold and primary balancing evaluation criteria required by 300.420(e)(9)(iii) of the NCP as set forth in Section 6 above. The alternatives that are evaluated for groundwater at this Site are:

- Alternative 1 – No Action;
- Alternative 2 – Source Control, Monitoring, and Institutional Controls; and
- Alternative 3 – Source Control, Monitoring, and Institutional Controls, with a Contingent Remedy.

Table 7-1 contains a summary of the comparative analysis for the groundwater remedial action alternatives, which presents a relative ranking for each alternative considered with respect to each other in USEPA's the seven NCP threshold and primary balancing criteria. The threshold criteria were evaluated as to whether they would or would not meet the NCP criteria. The ranking scale (4—for the primary balancing criteria (Excellent, followed by 3—Good, 2—Moderate, and 1—Poor) is based on anticipated positive to negative results for each criterion. For example, if minimal to no residual risk (under the detailed analysis criterion No. 3 - Long-Term Effectiveness and Permanence) is anticipated for an alternative, it is graded as “4Excellent.” These grades, or rankings, are discussed as appropriate in the follow sections.

The descriptions of the groundwater Remedial Alternatives and the cost estimates are based on the currently available data. The final extent of remediation in groundwater Remedial Alternatives 2 and 3 will be confirmed through a PDI and incorporated in the remedial design.

7.2 Alternative 1 – No Action

This alternative provides a baseline for comparing other alternatives. No remedial activities would be implemented with this alternative; however, concentrations of certain groundwater COCs should decrease through natural processes as they have in the past. Therefore, long-term human health risks for groundwater at the Site will remain similar to those identified in the BHHRA. Because there are no remedial activities, no additional

risks are posed to human health or the environment through implementation of this alternative, for example, no impacts to the existing habitat at the Site. There are no implementability issues or concerns and no costs associated with this remedial alternative.

7.2.1 Overall Protection of Human Health and the Environment

- Human Health Protection: This alternative does not include any actions to remediate or restrict access to groundwater. This alternative does not enhance current, naturally-occurring reductions in COC concentrations in groundwater and therefore ~~is ranked poor since it will~~does not help meet the NCP criterion of human health protection.
- Environmental Protection: Ecological exposures in groundwater were not considered in the BERA because groundwater is not a habitat of concern, and no risks have been identified in surface water that groundwater from the Site might flow to. Therefore, ecological risk is not applicable to the groundwater remedial alternatives.

7.2.2 Compliance with ARARs

- Chemical Specific ARARs: Existing concentrations of certain COCs in groundwater exceed their chemical specific ARARs. This alternative does not enhance current, naturally occurring reductions in COC concentrations in groundwater and therefore is ranked poor since it will not help meet the chemical specific ARARs (although the naturally occurring reductions that have been observed are expected to continue to occur). Given background conditions in the area of the Site, metals concentrations should remain stable. This alternative does not meet NCP criterion for chemical specific ARARs. Table 7-2 summarizes compliance with ARARs.
- Location Specific ARARs: Location specific ARARs are not applicable to this alternative, because there are no remedial activities.
- Action Specific ARARs: Action specific ARARs do not apply to this alternative because there are no remedial activities associated with this alternative.

7.2.3 Long-Term Effectiveness and Permanence

- Magnitude of Residual Risk: Because there are no remedial actions associated with this alternative, it is anticipated that potential future exposure of human

receptors to contaminants remaining in groundwater will continue to pose the magnitude of risk as evaluated in the BHHRA (although the naturally occurring reductions that have been observed are expected to continue to occur). This alternative is ranked poor with respect to the magnitude of residual risk.

- *Adequacy and Reliability of Controls*: Not applicable. No controls are proposed for this alternative.

7.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 1 includes natural processes to reduce COC concentrations but does not include treatment and therefore does not reduce the toxicity, mobility, or volume of COCs in groundwater through treatment. Therefore, it is ranked poor for this criterion.

- *Treatment Process used and Materials Treated*: This alternative does not employ remedial actions to reduce or treat groundwater COCs.
- *Amount of Hazardous Materials Destroyed or Treated*: This alternative does not employ remedial actions to reduce or treat groundwater COCs.
- *Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment*: This alternative does not employ remedial actions to reduce or treat groundwater COCs.
- *Degree to which Treatment is Irreversible*: This alternative does not employ remedial actions to reduce or treat groundwater COCs.
- *Type and Quantity of Residuals Remaining after Treatment*: This alternative does not employ remedial actions to reduce or treat groundwater COCs.
- *Whether the Alternative Would Satisfy the Statutory Preference for Treatment as a Principal Element*: This alternative does not employ remedial actions to reduce or treat groundwater COCs and would not satisfy the statutory preference for treatment.

7.2.5 Short-Term Effectiveness

- *Protection of Community During Remedial Actions*: Not applicable because no remedial actions are proposed in this alternative.
- *Protection of Workers During Remedial Actions*: Not applicable because no remedial actions are proposed in this alternative.
- *Environmental Impacts*: Not applicable because no remedial actions are proposed in this alternative.

- Time Until Remedial Action Objectives are Achieved: No active treatment is proposed for this alternative. The time to achieve the RAOs is unknown, but presumably will occur due to natural attenuation of the COCs through time, albeit at a slower rate than the other groundwater alternatives. Therefore, Alternative 1 is ranked poor for this criterion.

7.2.6 Implementability

Alternative 1 does not include remedial actions so implementability is not applicable.

- Ability to Construct and Operate the Technology: This alternative does not employ a remedy.
- Reliability of the Technology: This alternative does not employ a remedy.
- Ease of Undertaking Additional Remedial Actions, If Necessary: This alternative does not employ a remedy.
- Ability to Monitor Effectiveness of Remedy: This alternative does not employ a remedy.
- Ability to Obtain Approvals and Coordinate with Other Agencies: This alternative does not employ a remedy.
- Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity: This alternative does not employ a remedy.
- Availability of Necessary Equipment and Specialists: This alternative does not employ a remedy.
- Availability of Prospective Technology: This alternative does not employ a remedy.

7.2.7 Cost

Alternative 1 does not include remedial actions so there are no costs associated with it and this criterion is not applicable.

- Indirect Capital Cost (Design/Construction Oversight/Permits): Not applicable because no remedial action will be implemented under this alternative.
- Direct Capital Costs: Not applicable because no remedial action will be implemented under this alternative.
- Post-Construction Operation, Maintenance, and Monitoring Costs: Not applicable because no remedial action will be implemented under this alternative.
- Total Costs: Not applicable because no remedial action will be implemented under this alternative.

7.3 Alternative 2 – Source Control, Monitoring, and Institutional Controls

This alternative relies on source control and natural processes to achieve a reduction of groundwater COC concentrations. Based on existing data, it is assumed that source control will consist of remediating the area of test pit TP-09, where potential industrial wastes were observed. This test pit was located near and upgradient of monitoring well MW-3, which contained levels of benzene, 1,4-dioxane, and other COCs at concentrations above their GWQSSs. Remediation of the test pit TP-09 area is anticipated to take place during the remedial action for soil (unless soil Remedial Alternative 1 - No Action or Remedial Alternative 2 – Site Controls, is selected, in which case source control measures will be implemented as part of this alternative before monitoring begins). [Contamination identified at TP-09 will be excavated to the water table and disposed of off-Site. Confirmation sampling will be conducted after excavation.](#) Additional source areas may be identified visually or based on groundwater monitoring results indicating that COC concentrations are increasing in a specific area of the Site. Decision criteria for identifying additional source areas will be included in the PDI Work Plan and remedial design.

Should additional source areas that are adversely impacting groundwater be identified 1) during the PDI, 2) during implementation of the selected soil remedial action, or 3) during monitoring conducted as part of the groundwater remedy, additional source control activities may be required. Such source control methods may include excavation or capping of contaminated materials, depending on the conditions observed in each source area. The selected source control method(s) will be designed to achieve a reduction of groundwater COCs.

After the source area(s) has been remediated and the selected soil remedial actions are implemented, groundwater will be monitored. The monitoring program will meet USEPA and NJDEP requirements. Additional monitoring wells will likely be needed to evaluate the performance of this remedial alternative. The location of the new wells will be addressed in the PDI and design. COC concentrations in groundwater may temporarily increase following the implementation of the soil remedy due to disturbance of the soil. Therefore, a baseline will need to be established for COC concentrations through several rounds of sampling. If, as anticipated, groundwater concentrations remain stable or decline through time, the initial monitoring frequency used to establish the baseline may be reduced.

This alternative will include a Classification Exception Area (CEA) and a Well Restriction Area (WRA) as institutional controls, which would reduce the long-term human health risks by prohibiting groundwater use within the footprint of the affected area(s). ~~—In addition, the Hunt Club supply well (HC-1) will be closed in accordance with NJDEP regulations.~~

The objective of the source control component of this alternative is to help improve groundwater quality. Therefore, source control is discussed below in the evaluation of the seven threshold and primary balancing criteria for the purpose of comparing alternatives. However, for cost estimating, source control is included in the costs for soil Remedial Alternatives 3 through 5 because the source control action at location TP-09 would be implemented at the same time, and using the same equipment and procedures, as these soil remedial alternatives.

7.3.1 Overall Protection of Human Health and the Environment

- Human Health Protection: This alternative protects human health through removal of source material, which is expected to result in decreasing concentrations of the COCs. In addition, the CEA and WRA will notify the public of the presence of groundwater impacts and prevent human contact and use of the groundwater in the affected area. Overall, this alternative ~~provides good protection of~~ meets the NCP criterion for human health.
- Environmental Protection: Ecological exposures in groundwater were not considered in the BERA because groundwater is not a habitat of concern, and no risks have been identified in surface water that groundwater from the Site might flow to. Therefore, ecological risk is not applicable to the groundwater remedial alternatives.

7.3.2 Compliance with ARARs

- Chemical Specific ARARs: Existing concentrations of COCs in groundwater exceed chemical specific ARARs (Table 7-2). Concentrations of organic COCs (benzene and 1,4-dioxane) in groundwater are stable or decreasing under current conditions; if soil Remedial Alternative 2 (Site Controls) is selected, this trend is expected to continue, eventually meeting the chemical specific ARARs. If soil Remedial Alternatives 3 or 5 (i.e. capping) or Alternative 4 (i.e. excavation) are selected, concentrations are expected to decrease more rapidly and meet the chemical specific ARARs. Concentrations of metals that are above the PRGs

should remain stable. In any case, implementation of Alternative 2 is expected to result in a more rapid reduction of COC concentrations compared to Alternative 1 (no action), and ~~is rated good~~ meets the NCP criterion for compliance ~~with~~ chemical specific ARARs.

- Location Specific ARARs: This remedial alternative will comply with relevant location specific ARARs and ~~is ranked excellent~~ therefore meets this NCP criterion, as summarized in Table 7-2.
- Action Specific ARARs: This remedial alternative will comply with relevant action specific ARARs and ~~is ranked excellent~~ therefore meets this NCP criterion, as summarized in Table 7-2.

7.3.3 Long-Term Effectiveness and Permanence

- Magnitude of Residual Risk: Source control (i.e., excavation or capping) at TP-09 (and at other source areas, if any, identified during the remedial action) is anticipated to significantly reduce residual risk by eliminating or minimizing the potential for additional COC leaching to groundwater. A cap in groundwater source areas would likely be designed with a geomembrane to make it essentially impermeable to prevent infiltration of precipitation in the source areas. Institutional controls will further mitigate residual risk by preventing the use of groundwater where COC levels exceed ARARs. This alternative will provide good reduction of residual risk.
- Adequacy and Reliability of Controls: This alternative employs source control (i.e., excavation or capping), monitoring, and institutional controls that are widely used for groundwater remediation. Institutional controls are effective in preventing unauthorized human use of groundwater on Site and are therefore adequate and reliable. Source control is also a widely used, reliable technology for remediation of groundwater. The overall adequacy and reliability of these controls is good.

7.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 2 includes natural processes to reduce COC concentrations but does not include treatment and therefore does not reduce the toxicity, mobility, or volume of COCs in groundwater through treatment. Therefore, it is ranked poor for this criterion.

- *Treatment Process used and Materials Treated:* This alternative relies on source control and natural processes to reduce the groundwater COC concentrations. It does not employ treatment to augment reductions.
- *Amount of Hazardous Materials Destroyed or Treated:* This alternative relies on source control and natural processes to reduce groundwater COC concentrations, and does not employ treatment to augment reductions. The magnitude of the reduction in concentrations would depend on natural processes and will be observed through periodic groundwater monitoring.
- *Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment:* This alternative relies on source control and natural processes to reduce groundwater COC concentrations, and does not employ treatment to augment reductions.
- *Degree to which Treatment is Irreversible:* This alternative relies on source control and natural processes to reduce groundwater COC concentrations, and does not employ treatment to augment reductions.
- *Type and Quantity of Residuals Remaining after Treatment:* This alternative relies on source control and natural processes to reduce groundwater COC concentrations, and does not employ treatment to augment reductions.
- *Whether the Alternative Would Satisfy the Statutory Preference for Treatment as a Principal Element:* This alternative relies on source control and natural processes to reduce groundwater COC concentrations, and does not employ treatment to augment reductions. Therefore, it does not satisfy the preference for treatment.

7.3.5 Short-Term Effectiveness

- *Protection of Community During Remedial Actions:* Impacts on the community will be incurred during source control activities (to be implemented concurrent with the soil remediation activities) and will include, in part, truck traffic associated with waste transportation on local roads. The remedy also includes long-term groundwater monitoring which will require small teams of personnel to access the Site infrequently. Alternative 2 is rated excellent for protection of the community during remedial actions.
- *Protection of Workers During Remedial Actions:* This remedial alternative will be implemented in accordance with applicable OSHA requirements and a project-specific HASP. Implementation of the health and safety requirements and plans will effectively protect workers and mitigate worker risk. The construction

activities associated with this alternative are routine and the associated risks can be successfully managed. Alternative 2 is rated excellent for protection of the workers during remedial actions.

- *Environmental Impacts:* Source control activities will be undertaken within wetland areas and bog turtle habitat; however, the required precautions will be taken to protect these areas so environmental impacts associated with the source control action are expected to be limited. Any disturbance to these areas caused by the remedial activities will be restored as part of the remedial action. Environmental impacts associated with groundwater monitoring are minimal and mostly related to installation of new monitoring wells (if any are needed) and maintaining roads and paths necessary to access the wells. Alternative 2 is rated excellent with respect to minimizing environmental impacts.
- *Time Until RAOs are Achieved:* Groundwater data collected to date, prior to implementation of soil remedial actions, indicate that the concentrations of certain COCs are decreasing with time due to natural processes at the Site. Elimination of sources will speed this reduction compared to the no action alternative. Although COC concentrations may temporarily increase following disturbances to soil/groundwater during source control, it is expected that the rate of decrease in COC concentrations will accelerate after source control and soil remedial actions are completed. The time to achieve the RAOs will be evaluated through groundwater monitoring after source control and implementation of the soil remedial actions. Overall, Alternative 2 is rated moderate for time to achieve RAOs.

7.3.6 Implementability

- *Ability to Construct and Operate the Technology:* This alternative will involve source control, monitoring, and institutional controls, which are widely used technologies to remediate groundwater contamination. There are few if any implementability issues or concerns associated with this alternative; source control with monitoring is a common remediation technique for groundwater that has been used at many sites. Therefore, the ability to construct and operate the remedy is anticipated to be excellent.
- *Reliability of the Technology:* This alternative will involve source control, monitoring, and institutional controls, which are widely used technologies to remediate groundwater contamination. The reliability of these remedial technologies has been demonstrated at many sites and is expected to be excellent.

- *Ease of Undertaking Additional Remedial Actions, If Necessary:* This alternative will not restrict any additional remedial actions, if necessary. The ease of undertaking additional remedial actions, if necessary, for Alternative 2 is excellent.
- *Ability to Monitor Effectiveness of Remedy:* A monitoring plan will be developed in consultation with USEPA and NJDEP. The plan will be designed to provide high-quality data to allow evaluation of how COC concentrations are responding to the soil remedial action. This will allow the effectiveness of the remedy to be evaluated. The ability to monitor the effectiveness of Alternative 2 is excellent.
- *Ability to Obtain Approvals and Coordinate with Other Agencies:* This alternative will involve source control, institutional controls, and monitoring, which are widely used technologies to remediate groundwater contamination. New Jersey has a regulatory process for establishing CEAs and WRAs. Therefore, the ability to obtain approvals and coordinate with other agencies is anticipated to be excellent.
- *Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity:* Off-Site treatment, storage, and disposal services will be needed if excavation is selected for source control. The availability of these services with respect to source control measures is expected to be good.
- *Availability of Necessary Equipment and Specialists:* This alternative will involve source control, monitoring, and institutional controls, which are widely used technologies to remediate groundwater contamination. Therefore, the availability of necessary equipment and specialists is anticipated to be excellent.
- *Availability of Prospective Technology:* This alternative will involve source control, monitoring, and institutional controls, which are widely used technologies to remediate groundwater contamination. Therefore, the availability of the technology is anticipated to be excellent.

7.3.7 Cost

The relative costs of this alternative are anticipated to be more than Alternative 1. Monitoring could be performed using existing infrastructure and, if needed, additional groundwater monitoring wells. The detailed cost estimate of this alternative is provided in Table 7-3, and the summary of the cost estimate is below:

- *Indirect Capital Cost (Design/Construction Oversight/Permits):* \$34,200
- *Direct Capital Costs:* \$115,200
- *Post-Construction Operation, Maintenance, and Monitoring Costs:* \$1,195,000

- Total Costs: \$1,345,000

Assumptions, notes, and limitations considered during the development of the cost estimate for the alternatives are provided in Table 7-4.

The cost to remediate location TP-09 is included in soil Alternatives 3, 4, and 5 and assumes excavation of this area to the water table with off-Site disposal. If soil Alternatives 1 or 2 are selected, source control at location TP-09 would be added to the above costs. Based on the assumptions used in soil Alternatives 3, 4, and 5, excavation and off-Site disposal of the TP-09 area would add approximately \$900,000 to the above costs.

7.4 Alternative 3 – Source Control, Monitoring, and Institutional Controls with a Contingent Remedy

7.4.1 Overview of Remedial Alternative 3

Like groundwater Remedial Alternative 2, this alternative relies on source control and natural processes with subsequent monitoring and institutional controls to achieve a reduction in the concentrations of groundwater COCs. In addition, this alternative includes a contingent remedy that would be implemented to the extent practicable if it is determined during monitoring that restoration as indicated by the following three lines of evidence: (a) stable or decreasing concentrations of COCs (i.e., “stable”); or (b) a reduction in the aerial extent of the COCs (i.e., “shrinking”) is not occurring; and (c) the estimated timeframe to achieve ARARs is determined to be unreasonable. A description of this alternative is given below.

- Completion of source control and monitoring, as outlined in groundwater Remedial Alternative 2, to determine if restoration is occurring.
- If the data indicate restoration is not occurring, or if migration of the COCs outside of the landfill boundary is occurring, an active remedy may be implemented, to the extent practicable, to accelerate restoration. Active remedies may include additional soil excavation or in-situ treatment. The details of the metrics for determining whether restoration is occurring will be developed during the remedial design process. At a minimum, restoration will be assessed formally during the five-year review process. For costing purposes, the in-situ remedy is assumed to be a combination of biological and chemical treatment.
- Institutional controls, including implementation of the CEA and WRA, to restrict the use of the groundwater until RAOs are achieved.

Based on existing data, it is assumed that source control will consist of remediating the area of test pit TP-09, where potential industrial wastes were observed. This test pit was located near and upgradient of monitoring well MW-3, which contained benzene, 1,4-dioxane, and other COCs at concentrations above their GWQs. Remediation of the test pit TP-09 area is anticipated to take place during the remedial action for soil (unless soil Remedial Alternative 1 - No Action, or soil Remedial Alternative 2 – Site Controls, is selected, in which case source control measures will be implemented as part of this alternative before monitoring begins). [Contamination identified at TP-09 will be excavated to the water table and disposed of off-Site. Confirmation sampling will be conducted after excavation.](#) Additional source areas may be identified visually or based on groundwater monitoring results indicating that COC concentrations are increasing in a specific area of the Site. Decision criteria for identifying additional source areas will be included in the PDI Work Plan and remedial design.

Should additional source areas that are adversely impacting groundwater be identified during the PDI, implementation of the selected soil remedial action, or during monitoring conducted as part of the groundwater remedy, additional source control activities may be required. Source control methods may include excavation or capping of contaminated materials, depending on the conditions observed in each source area; the selected source control method(s) will be designed to achieve a reduction of groundwater COCs.

After the source area(s) has been remediated and the selected soil remedial actions are implemented, groundwater will be monitored to observe whether groundwater COC concentrations are stable or shrinking, and the estimated timeframe to achieve ARARs is determined to be reasonable. The monitoring program will meet USEPA and NJDEP requirements. Additional monitoring wells will likely be needed to evaluate the performance of this remedial alternative. The location of the new wells will be addressed in the PDI and design. COC concentrations in groundwater may temporarily increase following the implementation of the soil remedy due to disturbance of the soil. Therefore, a baseline will need to be established for COC concentrations through several rounds of sampling. If, as anticipated, groundwater COC concentrations remain stable or decline within a reasonable timeframe, the initial monitoring frequency used to establish the baseline may be reduced.

If COC concentrations in groundwater are not stable or shrinking and the estimated timeframe to achieve ARARs is determined to be unreasonable, a re-evaluation would be triggered to determine if additional remedial actions are needed. Performance measures for assessing whether restoration is occurring can be demonstrated using methods such

as concentration versus time plots, concentration versus distance plots or concentration isopleth maps. Plume stability may be demonstrated by well trend analysis using statistical methods such as Mann-Kendall or Linear Regression, or other methods or models as approved by USEPA. These performance measures will be developed during the remedial design process.

The contingent remedial actions may include one or more of the following remedial technologies:

- Additional source control;
- In-situ enhanced biodegradation;
- Phytoremediation; and/or,
- In-situ chemical oxidation.

The potential effectiveness and applicability of each of the alternatives are discussed later in this section.

As previously noted, the selection of the contingent remedy or remedies will be made if the monitoring data demonstrate that COC concentrations in groundwater are not stable or shrinking and the estimated timeframe to achieve ARARs is determined to be unreasonable, and will consider:

- The specific COCs that require additional remediation;
- The locations where the additional remediation is required; and
- The purpose of the additional remediation (e.g., to reduce concentrations, to prevent constituent migration, to accelerate COC concentration decreases, or other performance measures).

This alternative will include a CEA and a WRA as institutional controls, which would reduce the long-term human health risks by prohibiting groundwater use within the footprint of the affected area(s). [In addition, the Hunt Club supply well \(HC-1\) will be closed in accordance with NJDEP regulations.](#)

Source control and monitoring are common remediation technologies used in many groundwater remedies, and New Jersey has a regulatory process for establishing CEAs and WRAs, so their implementation is expected to be straightforward. The contingent remedies included in this alternative are each applicable for certain constituents; therefore, to the extent a contingent remedy is triggered, the most appropriate remedial technology or technologies can only be selected based on the monitoring results. While the implementability considerations are different for each contingent remedial technology, all are proven and widely used.

As discussed in Section 2.7.3, the results of the groundwater investigations conducted at the Site indicate that certain COCs are present at concentrations above their GWQSSs. The full list of groundwater COCs was provided in Section 4.2.2, and includes benzene, 1,4-dioxane, dichlorodifluoromethane, trichlorofluoromethane, PCBs, and certain SVOCs, PAHs, and metals. Some of these exceedances were observed only in a limited number of wells, or at concentrations only slightly above their GWQSSs. For metals, the concentrations are likely in part due to background conditions (i.e., naturally occurring). Based on the results of the groundwater investigations, and the COC fate and transport characteristics, the COCs that are most likely to require implementation of the contingent remedy are benzene and/or 1,4-dioxane. Potential contingent remedial technologies that may apply to these COCs are summarized below.

COC	Potential Contingent Remedial Technologies
Benzene	Aerobic enhanced biodegradation, anaerobic enhanced biodegradation, phytoremediation
1,4-Dioxane	Chemical oxidation, bioaugmentation, phytoremediation

The contingent remedial technology(ies) may be selected from these or other treatment options. New or innovative technologies may be developed that would be more appropriate than the options discussed here. Should monitoring results indicate that

treatment is required for other COCs, those treatment methods can be identified at that time.

All in-situ remedies, including the potential contingent remedial technologies, must be designed considering site-specific conditions. These include the physical properties of the aquifer, such as permeability and anisotropy which will control how much reagent can be injected and how/where the reagent flows. The chemical properties of the aquifer can also affect the performance of in-situ remedies. For example, high levels of organic material in the aquifer may reduce the effectiveness of chemical oxidants by being oxidized preferentially to the target COCs. As another example, in aquifers with some active biodegradation, enhanced biodegradation may be a preferred alternative because enhancing an ongoing process is usually simpler than introducing a new process. Bioaugmentation involves adding a new microbe that can degrade specific COCs (in this case, 1,4-dioxane) to an aquifer if the environment is favorable to that microbe's growth. Given the extensive vegetation present in areas of the Site, and the shallow water table, phytoremediation may be an applicable alternative as well. These Site-specific conditions will be evaluated as part of a remedial design to be conducted if the need for the contingent remedy is triggered.

The costs of this alternative would be low to relatively high. If only source control, monitoring, and institutional controls are required (no contingent remedy), the costs would be the same as Alternative 2. If a contingent remedy is implemented, the costs of this alternative could be high. The scope and costs of a contingent remedy cannot be accurately estimated now but, to meet the cost estimation requirements for this FS, a contingent remedy consisting of a combination of biological treatment and in-situ oxidation has been assumed.

The objective of the source control component of this alternative is to help improve groundwater quality. Therefore, source control is discussed below in the evaluation of the seven threshold and primary balancing criteria for the purpose of comparing alternatives. However, for cost estimating, source control is included in the costs for soil Remedial Alternatives 3 through 5, because the source control action at location TP-09 would be implemented at the same time, and using the same equipment and procedures, as these soil remedial alternatives. If soil Remedial Alternatives 1 or 2 are selected, source control at location TP-09 would be implemented prior to the start of groundwater monitoring.

7.4.2 Overall Protection of Human Health and the Environment

- Human Health Protection: This alternative protects human health through removal of source material and natural processes, which should result in decreasing concentrations of the COCs. In addition, institutional controls will notify the public of the presence of groundwater impacts and prevent human contact and use of the groundwater. If these measures are not sufficient, a contingent remedy or remedies will be implemented to actively treat the COCs. Therefore, this remedial alternative ~~provides excellent~~ meets the NCP criterion for protection of human health compared to the other groundwater alternatives.
- Environmental Protection: Ecological exposures in groundwater were not considered in the BERA because groundwater is not a habitat of concern, and no risks have been identified in surface water that groundwater from the Site might flow to. Therefore, ecological risk is not applicable to the groundwater remedial alternatives.

7.4.3 Compliance with ARARs

- Chemical Specific ARARs: Existing concentrations of COCs in groundwater exceed chemical specific ARARs (Table 7-2). Concentrations of organic COCs (benzene and 1,4-dioxane) in groundwater are stable or decreasing under current conditions; if soil Remedial Alternative 2 (Site Controls) is selected, this trend is expected to continue, eventually meeting the chemical specific ARARs. If soil Remedial Alternatives 3 or 5 (i.e. capping) or Alternatives 4 (i.e. excavation) are selected, organic COC concentrations are expected to more rapidly decrease and meet the chemical specific ARARs. Concentrations of metals should remain stable, if above the PRGs. Since this alternative includes a contingent remedy if needed to reduce COC concentrations in groundwater, it can provide additional remediation in response to monitoring results and therefore will ~~provide excellent~~ meet the NCP criterion for compliance with chemical specific ARARs compared to the other groundwater alternatives, as summarized in Table 7-2.
- Location Specific ARARs: This remedial alternative will comply with relevant location specific ARARs and ~~is ranked excellent~~ meets this NCP criterion, as summarized in Table 7-2.
- Action Specific ARARs: This remedial alternative will comply with relevant action specific ARARs and ~~is ranked excellent~~ meets this NCP criterion, as summarized in Table 7-2.

7.4.4 Long-Term Effectiveness and Permanence

- Magnitude of Residual Risk: ~~Source control (i.e., Excavation at TP-09 (and excavation or capping) at TP-09 (and~~ at other source areas, if any, identified during the remedial action) is anticipated to significantly reduce residual risk by eliminating or minimizing the potential for leaching of COCs to groundwater. A cap in groundwater source areas would likely be designed with a geomembrane to make it impermeable and thereby prevent infiltration of precipitation. Institutional controls will further mitigate residual risk by posing limitations on groundwater use, reducing the likelihood for direct exposure. Because this alternative includes a contingent remedy if needed to reduce COC concentrations in groundwater, it can provide additional remediation of COCs in response to monitoring results and therefore will further reduce residual risks. This alternative will provide excellent reduction of residual risk.
- Adequacy and Reliability of Controls: This alternative employs source control (i.e., excavation or capping) and institutional controls that are widely used for groundwater remediation. Institutional controls are effective in preventing unauthorized human use of groundwater on Site and are therefore adequate and reliable. Source control is also a widely used, reliable technology for remediation of groundwater. This alternative includes a contingent remedy if needed to reduce COC concentrations in groundwater and would use technologies that are best suited for the COCs and Site-specific conditions. Overall, the adequacy and reliability of this alternative is excellent.

7.4.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

As discussed below, the reduction of toxicity, mobility, and volume of COCs through treatment in Alternative 3 is rated good to excellent.

- Treatment Process used and Materials Treated: This alternative primarily relies on source control measures and natural processes to reduce the groundwater COCs, but also includes groundwater treatment options if needed based on monitoring results. The specific treatment process or processes will be developed as part of the remedial design, will be directly applicable to the COCs that monitoring indicates need treatment, and will be designed to work in the aquifer conditions at the Site. Therefore, Alternative 3 is rated excellent in terms of the treatment process used and the materials treated

- Amount of Hazardous Materials Destroyed or Treated: This alternative primarily relies on source control and natural processes to reduce groundwater COC concentrations. The contingent remedy, if implemented, would incorporate a treatment process or processes that would reduce the amount of COCs in groundwater. This alternative is considered excellent with respect to the amount of hazardous materials destroyed or treated.
- Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment: This alternative relies on source control measures and natural processes, and possibly treatment. Source control, including remediation of the area around TP-09 (and other such areas, if any, identified during the remedial action) is anticipated to significantly reduce the volume of COCs in groundwater by removing or containing the source of those COCs. The contingent remedy, if implemented, would incorporate a treatment process or processes that would reduce the toxicity, mobility, and volume of the COCs in groundwater. This alternative is considered excellent with respect to reducing the toxicity, mobility, and volume of COCs.
- Degree to which Treatment is Irreversible: Certain of the treatment methods will result in irreversible destruction of COCs, for example, the biological degradation of benzene. Other treatment methods, such as chemical reduction of metals, are irreversible under most geochemical conditions, but may be reversed under extreme geochemical conditions which are not expected to occur at the Site. Overall, Alternative 3 is rated good in the degree to which treatment is irreversible.
- Type and Quantity of Residuals Remaining after Treatment: Natural and enhanced treatment of organic COCs like benzene will result in complete destruction of the COCs so no residuals of these COCs will remain. It is anticipated that residuals of some COCs, e.g., dissolved metals, will remain to some degree. Overall, Alternative 3 is rated good with respect to the type and quantity of residuals remaining after treatment.
- Whether the Alternative Would Satisfy the Statutory Preference for Treatment as a Principal Element: This alternative includes treatment as a contingent remedy and therefore is ranked excellent since it satisfies the statutory preference for treatment.

7.4.6 Short-Term Effectiveness

- Protection of Community During Remedial Actions: Impacts on the community will occur during source control activities (to be implemented concurrent with the soil remediation activities) and will include, in part, truck traffic associated with waste transportation on local roads. The remedy also includes long-term groundwater monitoring which will require small teams of personnel to access the Site infrequently. If the contingent remedy is needed, small teams of personnel will need to access the Site frequently for a short period (estimated as several months). However, any in-situ groundwater treatment will take place in relatively remote locations, away from developed areas, and so no significant impact on the community is anticipated from this portion of the remedy. Overall, this alternative is rated excellent for protection of the community during remedial actions.
- Protection of Workers During Remedial Actions: This remedial alternative will be implemented in accordance with applicable OSHA requirements and a project-specific HASP. Implementation of the health and safety requirements and plans will effectively protect workers and mitigate worker risk. The construction activities associated with this alternative are routine and the associated risks can be managed successfully. This alternative is considered excellent with respect to protection of workers during remedial actions.
- Environmental Impacts: Source control activities will be undertaken within wetland areas and bog turtle habitat; however, the required precautions will be taken to protect these areas so environmental impacts associated with the source control action are expected to be limited. Any significant disturbance to these areas caused by remedial activities will be restored as part of the remedial action. Environmental impacts associated with groundwater monitoring are minimal and mostly related to installation of new monitoring wells (if any are needed) and maintaining roads and paths necessary to access the wells. There could be some environmental impacts associated with implementation of the contingent remedy. These could include (1) work in regulated areas such as the wetlands; and (2) the injection of chemical reagents into the aquifer. However, it is anticipated that these impacts will be relatively short-lived. Overall, this alternative is rated good with respect to minimizing environmental impacts.
- Time Until RAOs are Achieved: Groundwater data collected to date, prior to implementation of soil remedial actions, indicate that the concentrations of certain COCs are decreasing with time due to natural processes at the Site. Although COC concentrations may temporarily increase after remedial activities, it is expected

that the rate of decrease in COC concentrations would accelerate after source control and soil remedial actions are completed. The time to achieve the RAOs will be evaluated through groundwater monitoring after source control and implementation of the soil remedial actions. Should the groundwater monitoring results indicate that the contingent remedy is needed, use of a contingent remedy will achieve RAOs more quickly than Alternatives 1 and 2. This alternative is considered good with respect to time to achieve RAOs.

7.4.7 Implementability

- *Ability to Construct and Operate the Technology:* This alternative will involve source control, monitoring, institutional controls, and in-situ treatment (if needed) which are widely used technologies to remediate groundwater contamination. There are few if any implementability issues or concerns with either the basic components of this alternative, or the contingent remedy component; source control and in-situ treatment are both common remediation techniques that have been used at many sites. Therefore, the ability to construct and operate the remedy is anticipated to be excellent.
- *Reliability of the Technology:* This alternative will involve source control, monitoring, institutional controls, and in-situ treatment (if needed), which are widely used technologies to remediate groundwater contamination. The reliability of certain in-situ treatment methods can be limited by site conditions, like aquifer geochemistry. For example, biological and chemical treatments can have site-specific implementation challenges such as variable aquifer geochemical conditions or heterogeneity in the landfill that could interfere with reagent injections. However, as the Site is well-characterized, these conditions will be known and accounted for during selection, design, and implementation of any contingent remedy. Therefore, the reliability of the remedy is anticipated to be excellent.
- *Ease of Undertaking Additional Remedial Actions, If Necessary:* This alternative will not restrict any additional remedial actions, so the ease of undertaking any additional remedial actions is excellent.
- *Ability to Monitor Effectiveness of Remedy:* A monitoring plan will be developed in consultation with USEPA and NJDEP. The plan will be designed to provide high-quality data to indicate how COC concentrations are responding to remedial action(s). This will allow the effectiveness of the remedy to be evaluated, and if

any changes to the remedial approach are needed they can be identified promptly so the ability to monitor the effectiveness of the remedy is excellent.

- Ability to Obtain Approvals and Coordinate with Other Agencies: This alternative will involve source control, institutional controls, and monitoring, which are widely used technologies to remediate groundwater contamination. New Jersey has a regulatory process for establishing CEAs and WRAs. If a contingent remedy is implemented, additional approvals may be needed, such as a New Jersey Discharge to Groundwater Permit. In general, New Jersey has clear regulatory processes for obtaining such permits, but because the specific contingent remedy is not known, the ability to obtain these approvals cannot be evaluated at this time. Overall, the ability to obtain approvals and coordinate with other agencies is anticipated to be good.
- Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity: Off-Site treatment, storage, and disposal services will be needed if excavation is selected for source control. The availability of these services with respect to source control measures is expected to be good.
- Availability of Necessary Equipment and Specialists: This alternative will involve source control, monitoring, and institutional controls, and could also include in-situ treatment, which are widely used technologies to remediate groundwater contamination. Therefore, the availability of necessary equipment and specialists is anticipated to be excellent.
- Availability of Prospective Technology: This alternative will involve source control, monitoring, and institutional controls, and may also include in-situ treatment, which are widely used technologies to remediate groundwater contamination. Therefore, the availability of the technology is anticipated to be excellent.

7.4.8 Cost

If no contingent remedy is needed, the costs of this alternative would be the same as Alternative 2. If the contingent remedy is implemented, the costs for Alternative 3 would be much higher than Alternative 2. The detailed cost estimate of this alternative is provided in Table 7-5, and the summary of the cost estimate is below. Note that this estimate includes costs to implement a contingent remedy consisting of biological treatment and chemical treatment.

- Indirect Capital Cost (Design/Construction Oversight/Permits): \$365,600
- Direct Capital Costs: \$1,254,000

- Post-Construction Operation, Maintenance, and Monitoring Costs: \$1,195,000
- Total Costs: \$2,815,000

Assumptions, notes, and limitations considered during the development of the cost estimate for the alternatives are provided in Table 7-4.

The cost to remediate location TP-09 is included in soil Alternatives 3, 4, and 5 and assumes excavation of this area to the water table with off-Site disposal. If soil Alternatives 1 or 2 are selected, source control at location TP-09 would be added to the above costs. Based on the assumptions used in soil Alternatives 3, 4, and 5, excavation and off-Site disposal of the TP-09 area would add approximately \$900,000 to the above costs.

7.5 Comparative Analysis of Alternatives

The purpose of the comparative analysis is to identify and compare the pros and cons of the groundwater remedial action alternatives relative to each other using the information contained in the detailed analysis of alternatives. This comparison is organized around the seven threshold and balancing criteria described earlier in this report.

Table 7-1 presents the summary of the comparative analysis for the groundwater remedial action alternatives, which presents a relative ranking for each alternative considered with respect to each other in USEPA's NCP's seven threshold and primary balancing criteria. The threshold criteria were evaluated as to whether they would or would not meet the NCP criteria. The ranking scale (4—Excellent, followed by 3—Good, 2—Moderate, and 1—Poor) is based on anticipated positive to negative results for each criterion.

The following table summarizes the scores for the three groundwater alternatives, based on the scores in Table 7-1. As the scores are relative, not absolute, and all the criteria are weighted equally in the total score, the total score is not a definitive evaluation of the remedial alternative. Judgment must still be used in comparing the remedial alternatives and a reviewer may decide to weigh certain criteria more than others. However, the total scores do provide an overall indication of how well each alternative meets the USEPA's seven threshold and primary balancing criteria.

Remedial Alternative	Total Score
Alternative 1—No Action	10

Alternative 2—Source Control, Monitoring, and Institutional Controls	79
Alternative 3—Source Control, Monitoring, and Institutional Controls with a Contingent Remedy	96

7.5.1 Overall Protection of Human Health and the Environment

Alternative 1 is no action. This alternative does not enhance current, naturally-occurring reductions in COC concentrations in groundwater and therefore will not help meet the criterion of human health protection. Groundwater Alternatives 2 and 3 include source control, and also include institutional controls (CEA and WRA) consistent with NJDEP requirements, which will serve as notice to the public of the groundwater conditions at the Site. Alternative 3 includes a contingent remedy to reduce COC concentrations in groundwater should such a remedy be required based on groundwater monitoring results. Thus, Alternative 3 is ranked higher than Alternative 2, which is ranked higher than Alternative 1.

7.5.2 Compliance with ARARs

Alternative 1 will not meet the chemical specific ARARs and therefore is the least compliant with ARARs (lowest rank). Alternatives 2 and 3 both include measures (source control, monitoring, natural processes and, for Alternative 3, in-situ groundwater treatment if needed) to reduce the concentrations of COCs in groundwater with the goal of compliance with chemical-specific ARARs (New Jersey GWQSSs). Because it includes a contingent remedy, Alternative 3 is ranked higher than Alternative 2 in compliance with chemical specific ARARs. Alternatives 2 and 3 are equally compliant with location specific and action specific ARARs.

7.5.3 Long-Term Effectiveness and Permanence

Alternative 1 is no action and is therefore the least effective remediation option. Alternatives 2 and 3 will involve institutional controls, source control, natural processes, and monitoring. The long-term effectiveness and permanence of Alternatives 2 and 3 (if no contingent remedy is needed) is anticipated to be good to excellent. If the contingent remedy is required in Alternative 3, with proper O&M of biological or chemical treatment systems, the long-term effectiveness and permanence of Alternative 3 is expected to be excellent, however the effectiveness of in-situ remedies may be constrained by the aquifer

properties. These constraints can be evaluated and addressed during selection and design of the contingent remedy.

7.5.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives 1 and 2 do not include treatment and therefore do not meet the statutory preference for treatment as a principal element. Alternatives 2 and 3 both include natural process to reduce groundwater COC concentrations. If the contingent remedy is required, Alternative 3 has a treatment component that achieves USEPA's statutory preference to reduce toxicity, mobility, or volume of Site COCs through treatment. Therefore, Alternative 3 has the highest ranking in this category.

7.5.5 Short-Term Effectiveness

Alternative 1 involves no action and therefore has no short-term benefits to the Site. Alternatives 2 and 3 include source control, which is expected to have a beneficial effect by removing a source (or sources) of COCs to groundwater. However, that effect may require several years to be evident in groundwater monitoring wells located downgradient of the area where source removal is implemented. Alternative 3 may also include direct treatment of COCs in groundwater so its short-term effectiveness with respect to achieving RAOs is ranked better than for Alternative 2. Both Alternatives 2 and 3 will have short-term impacts to the local community, primarily in the form of construction traffic on local streets. [If the contingent remedy is required in Alternative 3](#), Alternative 3 will involve more work (for example, drilling, application of reagents, monitoring) which may be located in wetlands or other sensitive areas of the Site, potentially leading to some short-term environmental impacts. Overall, Alternatives 2 and 3 are ranked equivalently with regard to short-term effectiveness.

7.5.6 Implementability

This criterion is not applicable for Alternative 1 because no remedial action will be implemented. Alternatives 2 and 3 both include source control, monitoring, and institutional controls, which are all common, proven techniques that do not require unique equipment or materials, or have significant or difficult O&M requirements. Implementability of a contingent remedy for Alternative 3 is anticipated to be good to excellent. While biological and chemical treatments, if implemented as part of the contingent remedy, are widely used technologies for groundwater remediation, they can have site-specific implementation challenges such as variable aquifer geochemical conditions or heterogeneity in the landfill that could interfere with reagent injections.

However, these conditions will be known and accounted for during selection, design, and implementation of any contingent remedy. Overall, the implementability of Alternatives 2 and 3 is similar.

7.5.7 Cost

Table 7-6 summarizes the remedial construction cost estimates for the groundwater remedial alternatives. This criterion is not applicable for Alternative 1 because no remedial action will be implemented. Alternative 3 is the most expensive remedial alternative, followed by Alternative 2. The difference in estimated costs between Alternatives 2 and 3 is that the estimated cost for Alternative 3 includes implementation of the contingent remedy (biological treatment and chemical treatment). Therefore, Alternative 2 ranked best in terms of cost.

7.5.8 Summary

Alternative 1 involves no action, and therefore does not actively improve groundwater conditions relative to ARARs (although naturally occurring reductions have been observed and can be expected to continue to occur).

Alternative 2 includes source control, which is an essential component of most groundwater remedies. Implementation of this alternative is expected to have a beneficial impact on groundwater conditions. This benefit may not be observed in groundwater samples until a year or more after source removal is conducted because COC concentrations in groundwater may temporarily increase following the implementation of the soil/source control remedy due to disturbance of the soil. Therefore, a baseline will need to be established for COC concentrations through several rounds of sampling. This alternative also includes ongoing natural processes to reduce COC concentrations, but does not include treatment. The remedial components of Alternative 2 are straight-forward and readily implementable. Long-term monitoring will provide data to evaluate the effectiveness of the source control, the trajectory toward achieving RAOs, and the potential need to make adjustments to the remedy in the future.

Without implementation of the contingent remedy component, Alternative 3 is the same as Alternative 2 in all respects and would have the same relative rating with respect to the [USEPA NCP](#) threshold and balancing criteria. Because it includes a contingent remedy ~~to be implemented if needed based on monitoring results~~, Alternative 3 is more likely than Alternative 2 to meet chemical specific ARARs, should be more effective, and should reduce toxicity, mobility, and volume of COCs through treatment. Like



Alternative 2, Alternative 3 includes long-term monitoring so the effectiveness of the remedy can be assessed, and adjustments can be made, if needed. When the contingent remedy is included, Alternative 3 is approximately twice the cost of Alternative 2.

8. SUMMARY AND CONCLUSIONS

This FS Report is based on a thorough study of environmental conditions at the Rolling Knolls Landfill Superfund Site, implemented in conjunction with USEPA and NJDEP. The Site RI included multi-phased investigations of all environmental media, including soil, groundwater, surface water, sediment, sub-slab soil gas, and indoor air. In addition, human health and ecological risks have been quantified. Based on the results of this work, remediation of soil and groundwater at the Site is needed to reduce risks to human health and the environment, and to meet ARARs.

The data available are more than adequate to identify and compare remedial alternatives. This has been completed through a multi-phase process including the TMCT, DSRA, and this FS Report. The evaluation is based on the expectation that the landfill portion of the Site will not be used in the future for any residential, commercial, industrial, recreational or other purposes. Therefore, the only potential human receptors on the landfill portion of the Site are trespassers and there will be no groundwater use at the Site.

Based on the results of prior screening of remedial options, the following five Remedial Alternatives for soil were evaluated in this FS:

- 1) No Action;
- 2) Site Controls (i.e., Institutional Controls and Access Restrictions);
- 3) Site Controls, Capping of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals;
- 4) Site Controls, Excavation and Off-Site Disposal of Selected Area to Reduce Overall Risk, Remediation of APCs, and Remediation of Non-Vegetated Areas with Soil Sample Results Above Remediation Goals; and,
- 5) Site Controls and Capping of All Landfill Material.

The following table summarizes the characteristics of each soil Remedial Alternative when compared to [USEPA's the NCP](#) evaluation criteria.

Evaluation Criteria	Soil Remedial Alternatives				
	1	2	3	4	5
<u>Threshold Criteria</u>					
Overall Protection of Human Health and the Environment	NA	<u>Poor to Moderate* Docs Not Meet NCP Criterion</u>	<u>Good to Excellent* Meets NCP Criterion</u>	<u>Good to Excellent* Meets NCP Criterion</u>	<u>Moderate to Excellent* Meets NCP Criterion</u>
Compliance with ARARs	NA	<u>Poor to Excellent* Docs Not Meet NCP Criterion</u>	<u>Excellent Meets NCP Criterion</u>	<u>Excellent Meets NCP Criterion</u>	<u>Excellent Meets NCP Criterion</u>
<u>Primary Balancing Criteria</u>					
Long-Term Effectiveness and Permanence	NA	Poor to Moderate*	Excellent	Excellent	Excellent
Reduction of Toxicity, Mobility, and Volume Through Treatment	NA	Poor	Poor to Excellent*	Poor to Excellent*	Poor to Excellent*
Short-Term Effectiveness	NA	Poor to Excellent*	Good to Excellent*	Moderate to Good*	Poor to Good*
Implementability	NA	Excellent	Excellent	Moderate to Excellent*	Moderate to Excellent*
Costs	NA	\$761,000	\$15,541 16,525,000 to \$21,099,000	\$32,426831,000 to \$57,792,000	\$54,261 55,430,000

NA - Not Applicable

NCP – National Contingency Plan

For Soil Alternatives 3 and 4, the range of costs reflects differing remedial approaches included within the alternative.

*includes ranges within the sub-categories

The No Action alternative has no remedial components and provides no protection, and therefore it was not compared to the evaluation criteria. Soil Alternative 2, Site Controls, provides some protection to potential trespassers and prevents future use of the Site through institutional controls at a low cost. However, it does not alter ecological risk from baseline conditions, and does not comply with all ARARs.

Alternatives 3 and 4 remediate the Selected Area to reduce the overall risk to potential trespassers and to vermivorous birds and mammals, and include remediation of the APCs

and mostly non-vegetated areas to further reduce risks. Both alternatives provide excellent overall protection, comply with ARARs, and provide excellent long-term effectiveness. However, Alternative 3 has better short-term effectiveness, fewer impacts to the community, and is more cost effective than Alternative 4. In addition, due to implementability issues, Alternative 4 becomes less favorable compared to Alternative 3 ~~as the~~ due to potential excavation depth increases.

Alternative 5 remediates the entire landfill portion of the Site and is similar to Alternatives 3 and 4 in terms of overall protection, compliance with ARARs, and long-term effectiveness. However, this alternative will have the greatest impact on the community because of the number of trucks needed to import fill material to cap the entire landfill (three to five times more trucks), and because it destroys the existing habitat at the Site, replacing it with a new habitat (grasslands) that have lower ecological value. Alternative 5 is also more expensive than any other alternative, except that Alternative 4 may be similar to the cost of Alternative 5 depending upon the depth of excavation.

Based on the results of prior screening of remedial options, the following three Remedial Alternatives for groundwater were evaluated in this FS:

- 1) No Action;
- 2) Source Control and Monitoring; and,
- 3) Source Control and Monitoring with a Contingent Remedy and Institutional Controls.

The following table summarizes the characteristics of each groundwater Remedial Alternative when compared to ~~USEPA's~~ the NCP evaluation criteria.

Evaluation Criteria	Groundwater Remedial Alternatives		
	1	2	3
<u>Threshold Criteria</u>			
Overall Protection of Human Health and the Environment	NA or Poor <u>*Does Not Meet MCP Criterion</u>	NA or Good <u>*Meets NCP Criterion</u>	NA or Excellent <u>*Meets NCP Criterion</u>

Evaluation Criteria	Groundwater Remedial Alternatives		
	1	2	3
Compliance with ARARs	NA or Poor *Does Not Meet NCP Criterion	Good to Excellent*Meets NCP Criterion	ExcellentMeets NCP Criterion
<u>Primary Balancing Criteria</u>			
Long-Term Effectiveness and Permanence	NA or Poor*	Good	Excellent
Reduction of Toxicity, Mobility, and Volume Through Treatment	Poor	Poor	Good to Excellent*
Short-Term Effectiveness	NA or Poor*	Moderate to Excellent*	Good to Excellent*
Implementability	NA	Good to Excellent*	Good to Excellent*
Costs	\$0	\$1,345,000	\$2,815,000

NA - Not Applicable

NCP -National Contingency Plan

*includes ranges within the sub-categories

Alternative 1 involves no action, and therefore does not actively improve groundwater conditions relative to ARARs (although naturally occurring COC reductions have been observed and can be expected to continue to occur).

Alternative 2 includes source control, which is an essential component of most groundwater remedies, and monitoring. It also includes establishment of institutional controls (CEA and WRA). After source control is implemented, COC concentrations in groundwater will be reduced by ongoing natural processes. The remedial components of Alternative 2 are straight-forward and readily implementable. Long-term monitoring will provide data to evaluate the effectiveness of the source control, the trajectory toward achieving RAOs, and the potential need to make adjustments to the remedy in the future.

Without implementation of the contingent remedy component, Alternative 3 is the same as Alternative 2 in all respects and would have the same relative rating with respect to the USEPA NCP threshold and balancing criteria. Because it includes a contingent remedy to be implemented if needed based on monitoring results, Alternative 3 is more likely



than Alternative 2 to meet chemical specific ARARs, will be more effective, and will reduce toxicity, mobility, and volume of COCs through treatment. Like Alternative 2, Alternative 3 includes long-term monitoring so the effectiveness of the remedy can be assessed and adjustments can be made, if needed. When the contingent remedy is included, Alternative 3 is approximately twice the cost of Alternative 2.

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TABLES

FIGURES

